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Final Record of Decision

**Palermo Wellfield
City of Tumwater
Thurston County, Washington**

October 1999



DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Palermo Wellfield
City of Tumwater
Thurston County, Washington

CERCLIS Identification Number
WA 0000026534

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Palermo Wellfield in Tumwater, Washington, which was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, and, to the extent practicable, the National Contingency Plan. This decision is based on the administrative record for this site.

The remedy was selected by the U.S. Environmental Protection Agency (EPA). The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances. Trichloroethene (TCE) and tetrachloroethene (PCE) in surface water, groundwater, and PCE in soils at the site represent threats to human health.

DESCRIPTION OF THE SELECTED REMEDIES

The selected remedy is the only response action planned for the Site. The selected remedy includes extraction and treatment of the principal threat waste (PCE in soils under the Southgate Dry Cleaners) at the site. The following components of the remedy have already been completed as a Removal Action by EPA in 1997 and 1998:

- Installation of a wellhead treatment system, designed to meet drinking water standards for PCE and TCE, at the Palermo Wellfield. The system is being operated and maintained by the City of Tumwater.
- Installation of a soil vapor extraction (SVE) system and operation of that system for approximately 1½ years. The system was designed to remove PCE from the vadose zone under the Southgate Dry Cleaners. These soils are source materials constituting a principal threat to the drinking water aquifer at the site.

The following components of the remedy will be implemented upon execution of this Record of Decision:

- Installation of a french drain west of the residences on Rainier Avenue to collect groundwater containing PCE and TCE that is surfacing at the base of the Palermo Bluff. The purpose of the french drain is to sufficiently lower the groundwater table so that water containing volatile contaminants will not collect in the crawlspaces below the residences along Rainier Avenue. Pounded water in the crawlspaces poses a risk to human health (based on theoretical calculations) because PCE and TCE vapors are emitted from the water into the homes. The collected water will be transported to the City of Tumwater Municipal Golf Course via an existing storm sewer and treated in a constructed lagoon using aeration. The treated water will be discharged to the Deschutes River via an existing ditch. The french drain may be supplemented by the installation of ventilation systems for the crawlspaces if design analysis determines it is necessary.

- Evaluation of standing water throughout the Palermo neighborhood to determine if remedial action is needed in other parts of the neighborhood. If remedial action is determined to be necessary, it will consist of lowering the groundwater table under the affected homes and/or venting the crawlspaces of the affected homes.
- Notification of property owners, government officials, and well drillers about the extent of the area of groundwater containing PCE and TCE to assure that no supply wells will be inadvertently drilled into the plume of groundwater contamination.
- Continued operation of the SVE system at Southgate Mall until cleanup goals for PCE in soil beneath the Mall are met.
- Monitoring of trends in TCE and PCE concentrations in groundwater and surface water, the effects of natural attenuation, and the effectiveness of the treatment systems. Natural attenuation will be monitored both to assess its effectiveness as part of the overall remedy, and to assess any changes in the occurrence of breakdown chemicals such as vinyl chloride.

STATUTORY DETERMINATIONS

The selected remedial actions protect human health and the environment, comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial actions, and are cost-effective.

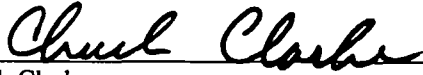
This remedy utilizes permanent solutions and alternative treatment or resource recovery technologies to the extent practicable and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because these remedies will result in hazardous substances remaining above health-based levels at the site, a review will be conducted within 5 years after the remedial action commences (and at 5-year intervals thereafter) to ensure that the remedies continue to provide adequate protection of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record file for this site.

- Chemicals of concern (COCs) and their respective concentrations. (See Section 5.5)
- Baseline risk represented by the COCs. (See Section 6.2.4.3)
- Cleanup levels established for COCs and the basis for these levels. (See Section 7.2)
- How the source materials constituting principal threats are addressed. (See Section 11.1)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD. (See Section 6.2)
- Potential land use and groundwater use that will be available at the site as a result of the selected remedy. (See Section 10.4)
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected. (See Section 10.3)
- Key factor(s) that led to selecting the remedy. (See Section 10.1)



Chuck Clarke
Regional Administrator, Region 10
United States Environmental Protection Agency

11/14/99
Date

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ABBREVIATIONS AND ACRONYMS

ADSDR	Agency for Toxic Substances and Disease Registry
AQUIRE	Aquatic Toxicity Information Retrieval Database
ARAR	applicable or relevant and appropriate requirement
ASIL	acceptable source impact limit
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	chemical of concern
CT	central tendency
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquids
E&E	Ecology and Environment, Inc.
Ecology	Washington State Department of Ecology
Eh	Redox potential
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FS	feasibility study
FWQC	Federal Water Quality Criteria
gpm	gallons per minute
GW	groundwater
HDPE	high-density polyethylene
HI	hazard index
HPA	Hydraulics Project Approval
HQ	hazard quotient
HRC™	proprietary product of Regenesiis, Inc.
IRIS	Integrated Risk Information System
L	liter
MCL	maximum contaminant level
Mft ³	million cubic feet
µg	microgram
Mgal	million gallons
mg/kg	milligrams per kilogram
MTCA	Washington State Model Toxics Control Act
MTL	materials testing laboratory
MW	monitoring well
NAPL	non-aqueous phase liquids

ABBREVIATIONS AND ACRONYMS (Continued)

NCEA	National Center for Environmental Assessment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTR	National Toxics Rule
O&M	operation and maintenance
OAPCA	Olympic Air Pollution Control Authority
ORC™	proprietary product of Regenesis, Inc.
PCE	tetrachloroethene
PRG	preliminary remedial goal
PRP	potentially responsible parties
RA	risk assessment
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RG	remediation goal
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SF	slope factor
START	Superfund Technical Assessment and Response Team
STV	screening toxicity value
SVE	soil vapor extraction
SW	surface water
TCE	trichloroethene
TSD	treatment, storage, or disposal
UCL	upper confidence limit
URSG	URS Greiner, Inc.
VOC	volatile organic compound
WDOT/WSDOT	Washington State Department of Transportation

DECISION SUMMARY

1.0 INTRODUCTION

This Decision Summary provides a description of the site-specific factors and analyses that led to selection of the remedy for the Palermo Wellfield Superfund Site (Site). It includes information about the Site background, the nature and extent of contamination, the assessment of human health and environmental risks, and the identification and evaluation of remedial alternatives.

The Decision Summary also describes the involvement of the public throughout the process, along with the environmental programs and regulations that may relate to or affect the alternatives. The Decision Summary concludes with a description of the remedy selected in this Record of Decision (ROD), and a discussion of how the selected remedy meets the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Documents supporting this Decision Summary are included in the Administrative Record for the Site. Key documents include the Final Remedial Investigation/Feasibility Study (RI/FS) and the Proposed Plan for the Site.

This site has not been divided into operable units and this document is the only ROD planned for this site.

2.0 SITE NAME, LOCATION, DESCRIPTION, AND HISTORY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The "Palermo Wellfield Superfund Site" (CERCLIS I.D. Number WA 0000026534) study area lies within the Puget Sound basin of western Washington. The site is located within the City of Tumwater (City) in Thurston County, Washington. The Remedial and Removal Actions described in this ROD have been and will be conducted by EPA utilizing the Superfund trust fund. EPA has identified potentially responsible parties (PRPs) and will attempt to recover federal funds expended in responding to the contamination at the site. The State of Washington has provided support concerning State of Washington cleanup requirements.

Soil and groundwater within the study area are contaminated with tetrachloroethene (PCE) and trichloroethene (TCE). These two chemicals constitute the chemicals of concern (COCs) at the site. The study area includes the Palermo Wellfield and Palermo neighborhood, both located within the Deschutes River Valley, and the adjacent uplands to the west (Figure 2-1). The upland area is approximately 60 feet higher in elevation than the river valley. Multiple sources of PCE and TCE contamination have been identified in the upland area. The Deschutes River Valley trends generally north-south with river flow to the north-northwest toward Budd Bay Inlet of Puget Sound.

The Palermo neighborhood consists of approximately 50 houses. The upland area is basically commercial consisting of restaurants, motels, gas stations, government facilities, and small businesses. A plume of groundwater contaminated with TCE and PCE originates at several businesses in the commercial area and flows under the Palermo neighborhood to the Wellfield for a total distance of approximately ½ mile.

The Palermo neighborhood is bounded on the west by the base of the bluff that separates the valley from the upland area to the west; on the east by the City of Tumwater Municipal Golf Course; on the north by M Street; and on the south by the Palermo Wellfield and open land (Figure 2-1). Groundwater seepage from the bluff face results in surface water that tends to pond at the base of the bluff, immediately west of the eight westernmost residential properties of the Palermo neighborhood. These properties are located along the western side of Rainier Avenue, south of M Street.

Even during the summer months, the yards of the Rainier Avenue residences are at times saturated. As a consequence, a drainage structure exists in the area of the ponded water, oriented north-south along the western property line of the eight Rainier Avenue residences. The drainage

structure consists of a combination of small diameter pipes and an open ditch. At least one resident has constructed a side ditch that drains his backyard to the drainage structure. Several of the residences are equipped with crawlspace sump pumps that discharge to the drainage structure. The structure passes underneath M Street in an approximately 6-inch-diameter concrete culvert, and constitutes the beginning of the stormdrain system beneath the street. The stormdrain alignment is beneath M Street, flowing to the east, with an outfall to an open ditch at the golf course. The ditch is joined by other surface water drainage features, and the combined flow eventually outlets into the Deschutes River.

The Palermo Wellfield comprises six production wells (TW-2, TW-3, TW-4, TW-5, TW-6, and TW-8) that provide approximately 50 percent of the City of Tumwater water demand. Screen depth intervals in feet below ground surface (bgs) for these production wells are:

- TW-2: 80 to 92
- TW-3: 60 to 96
- TW-4: 60 to 90
- TW-5: 82 to 115
- TW-6: 91 to 120
- TW-8: 70 to 90

The Palermo Wellfield location is shown on Figure 2-1. The water supply wells are generally pumped at approximately 300 to 500 gallons per minute (gpm) each, depending on demand. As expected, peak demand is usually during the summer months.

In addition to the City of Tumwater production wells, Pabst Brewing Company maintains 11 water production wells (TW-18 through TW-26, TW-39, and TW-58) west of the Deschutes River and north-northeast of the Palermo Wellfield. The wellfield location is shown in Figure 2-1. Historically, each of these wells was pumped at approximately 200 to 300 gpm continuously, with cycled increases up to approximately 500 to 600 gpm each. Currently, TW-24 is the only well being pumped (continuous 300 gpm) in the southern portion of the brewery wellfield. The Pabst Brewing Company groundwater quality monitoring program includes regular sample collection from TW-24, for volatile and semivolatile organic analyses. No volatile or semivolatile compounds have been detected in groundwater samples collected from TW-24, with the last sample collected and analyzed on February 11, 1999.

Wells TW-21 and TW-39 are periodically pumped for irrigation at the golf course. These wells are located approximately 2,500 feet east of the wellfield. These wells are only pumped during the driest parts of the summer.

The discussion of remedial alternatives in this ROD refers to "action areas," which consist of the Chevron service station, Southgate Mall (Southgate), Brewery City Pizza, and the base of the Palermo Bluff. Three of these action areas are sometimes grouped for discussion and referred to as "upland action areas," consisting of Chevron, Southgate, and Brewery City Pizza.

Action areas are those locations currently underlain by significant volumes of soil or groundwater (or both) containing relatively higher concentrations of COCs, as compared to the remainder of the site. In some cases, "source" areas are not "action" areas because no significant contamination remains in the source area (such as the Washington State Department of Transportation Materials Testing Laboratory [WDOT MTL]). Action areas are also locations at which remediation can be feasibly performed. For example, although high COC concentrations are likely to exist in groundwater beneath Capitol Boulevard between Brewery City Pizza and Southgate, it is more feasible to remediate groundwater at Brewery City Pizza and Southgate than directly beneath Capitol Boulevard.

Because of the higher COC concentrations identified in these areas, action areas are considered "reservoirs" of contamination that may contribute to future contamination of downgradient groundwater. Action areas may be, but are not necessarily, "sources" in the sense of COC origin.

2.2 SITE HISTORY

In 1931, the city installed a public water supply well in the middle of what was to later become the Palermo Wellfield, to provide service to the rapidly growing population. Meanwhile, the Olympia Brewery continued its expansion of bottling facilities east of the Deschutes. In the 1970s, the Brewery developed a 260-acre recreational facility along the Deschutes, including a golf course, athletic complex, and upgrading of brewery production supply wells just east of the Palermo neighborhood. It was at this time of urban development that retail establishments and state government facilities were being constructed adjacent to the Trosper Road interchange of the interstate highway.

As described in the RI, spills or disposal of volatile organic compounds (VOCs) from one or more sources and likely dating from the early 1970s resulted in the contamination that currently affects the water being drawn by the Palermo Wellfield. The estimated date (early 1970s) of the inception of VOC releases at the sources is based on the results of mathematical modeling of contaminant movement, the development history of the area, and the responses received from WDOT and Southgate Dry Cleaners on the 104E query forms. Both the TCE and PCE contaminant plumes evolved into thin elongated zones of contamination aligned parallel to the local groundwater flow direction (slightly north of due west to east).

The Palermo Wellfield also created a "shadow zone" east of the wellfield beyond which contamination apparently did not migrate. This had the effect of inhibiting the direct migration of TCE in groundwater toward the brewery wells in the valley and also toward the Deschutes River.

The City of Tumwater collected and analyzed composite samples from the Palermo Wellfield beginning in 1988. TCE was first detected at 0.7 micrograms per liter ($\mu\text{g/L}$). As a result of this detection the City sampled each individual well. This sampling detected TCE in wells TW-2, TW-4, and TW-5 at concentrations ranging from 1.1 to 12.6 $\mu\text{g/L}$ and no detections in the other three wells. Followup sampling was conducted from August 12 to August 22, 1993. Three to six water samples each were collected from TW-2 through TW-6 and TW-8 during that time. TCE was detected in all the samples collected from TW-2, TW-4, and TW-5 at concentrations ranging from 0.9 to 14 $\mu\text{g/L}$, with the highest concentrations detected in the samples collected from TW-2. TCE was not detected in samples collected from TW-3, TW-6, and TW-8. As a result of these detections, the City removed the three affected wells from service. TCE has been consistently detected in water samples from TW-2 since 1993 with a general decrease in concentration over time.

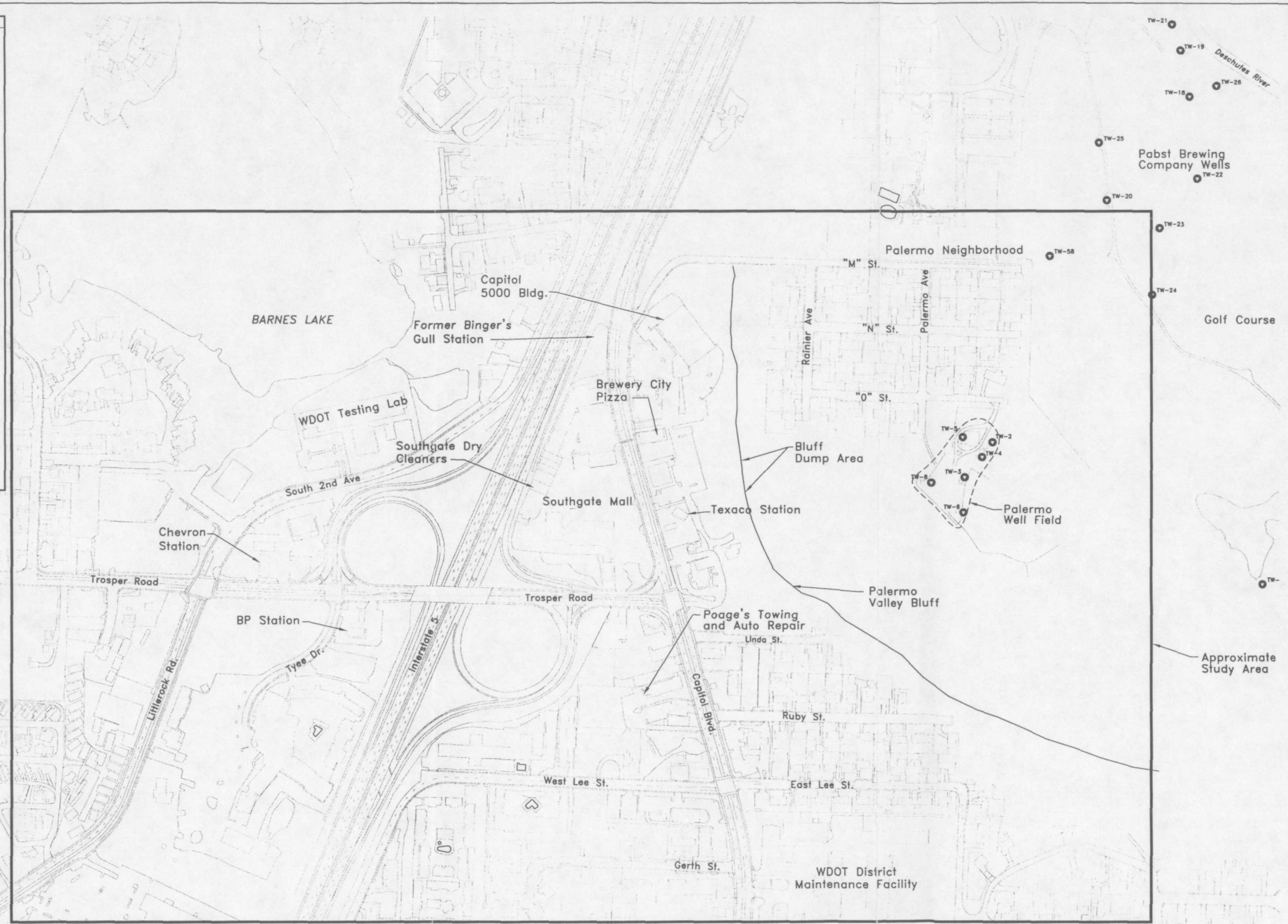
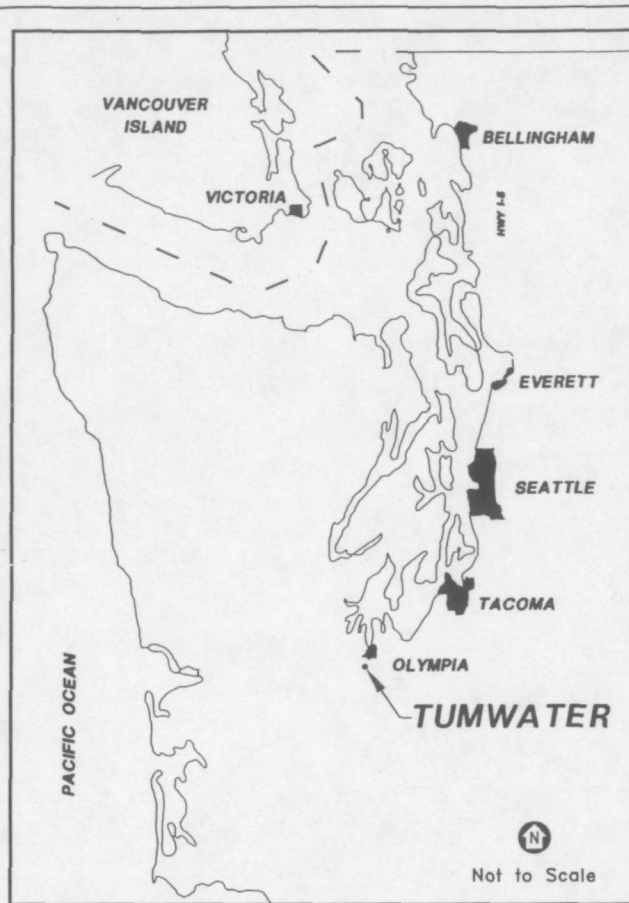
After discovery of TCE contamination at the Palermo Wellfield, the City and Ecology began looking for potential sources of the contamination in the commercial area upgradient to the wellfield. In late 1993 a dry well was discovered at the South Gate Dry Cleaners where the dry cleaning solvent PCE was spilled or disposed of. Sampling confirmed the presence of PCE in the dry well and in the soils under the dry well. In the Spring of 1994 the owner of the dry cleaners removed the dry well.

Previous investigations (in advance of the RI/FS) have been conducted by Pacific Groundwater Group for the City of Tumwater, and Roy F. Weston, Inc., and Ecology and Environment, Inc. for EPA. These investigations have resulted in soil and groundwater sampling at approximately 109 GeoProbe™ locations, and the installation of 11 groundwater monitoring wells, 6 vapor monitoring wells, and 6 vapor extraction wells. These studies also included air screening and surface water sampling in the vicinity of homes at the base of the Palermo Bluff. URS Greiner, Inc. has recently concluded remedial investigation/feasibility study (RI/FS) field activities, which included soil and groundwater sampling at 37 GeoProbe™ locations and 2 soil boring locations, installation of 12 groundwater monitoring wells, collection of surface water samples at 19 locations, and quarterly sampling of 23 monitoring wells. The RI/FS was published in May 1999, as two separate documents.

Early cleanup actions have been implemented at the Palermo Wellfield. EPA installed a soil vapor extraction (SVE) system at one of the upland action areas, Southgate Dry Cleaners, in March of 1998. The SVE system has been used to remove VOC vapor from the soil above the groundwater table beneath a portion of the mall centered on the Dry Cleaners. Since installation,

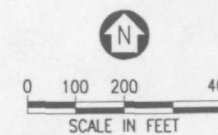
the system has removed approximately 410 pounds of PCE. The vapor stream removed by the SVE system has been treated using granular activated carbon.

EPA completed installation of an air-stripping system at the Palermo Wellfield in February 1999 to remove volatile contaminants from groundwater prior to blending and distribution. As a result of the treatment system, the City put wells TW-2, TW-4, and TW-5 back into service. Monitoring conducted after completion of the treatment system did not show any detections of TCE or PCE in the treated water. The treatment system has been turned over to the City and they are operating and maintaining the system.



Legend
 TW-B Drinking Water Well

Palermo Wellfield Superfund Site
 Tumwater, WA
 ARCS EPA
 REGION 10



URS Greiner

Figure 2-1
Study Area

3.0 SITE ENFORCEMENT ACTIVITIES

The EPA conducted investigations at the site in 1994 and 1995. The results of these investigations are contained in the Expanded Site Inspection Report for the Palermo Wellfield dated April 1996. Based on these investigations, EPA proposed the site for the National Priorities List (NPL) on December 20, 1996. The site was added to the NPL on April 1, 1997.

The EPA began work on the RI/FS in mid-1997 and completed the RI/FS in mid-1999. The EPA concurrently initiated removal actions at the site to address immediate risks to human health and the environment from PCE and TCE in soil and groundwater. An Action Memorandum for the Removal Actions was issued on July 3, 1997. One component of the removal action included installation and operation of an SVE system at the Southgate Dry Cleaners. The SVE system began operation on March 24, 1998. As of March 1999, an estimated 410 pounds of PCE have been removed from the soil by the SVE system, and the system remains in operation.

A second component of the removal action was installation of two air strippers at the City of Tumwater's Palermo Wellfield for treatment of well water. Construction of the air stripping system was completed in February 1999. The air strippers are sized to treat 1,000 gpm each. One stripper is plumbed to the three wells with TCE contamination, and one is plumbed to the remaining three wells. The air strippers are intended to remove TCE from the pumped water.

Prior to initiating the above removal action, EPA notified the owner of the Southgate Shopping Mall and past owners of Southgate Dry Cleaners of their potential liability and offered them the opportunity to conduct all or part of the removal actions EPA determined were necessary to conduct. EPA did not have sufficient information to notify other responsible parties at that time. None of the PRPs accepted the offer to conduct all or portions of the removal actions.

As a result of information collected during the Remedial Investigation and further analysis of data previously collected, EPA requested information from a number of potential sources of TCE/PCE contamination. These letters were mailed in mid-1998. As a result of these responses and other information, EPA notified 2 additional parties (Chevron and the Washington Department of Transportation) in August 1999 of their potential liability for the funds expended by EPA in responding to the problems at the Superfund site. In August 1999 EPA also notified former owners of the Southgate Dry Cleaners, which were not previously notified, of their potential liability.

4.0 COMMUNITY RELATIONS

The EPA has issued a number of Fact Sheets providing the status of EPA activities at the site throughout the Superfund process. Fact Sheets were released October 6, 1994, May 24, 1995, May 30, 1996, December 20, 1996, March 3, 1997, August 5, 1997, November 1, 1997, January 7, 1998, October 1, 1998, March 3, 1999, and July 1, 1999. The Fact Sheets were sent to an extensive mailing list of businesses and residents in the area as well as local officials.

A public meeting was held on December 11, 1997 to inform the public about the remedial and removal activities which were about to begin.

A Community Relations Plan for the site was finalized on February 1998.

The RI/FS Report and Proposed Plan for the Palermo Wellfield site were released to the public in August of 1999. These two documents were made available to the public in both the Site File in EPA's Seattle office and in the information repository maintained at the Tumwater Regional Library. The notice of availability of these two documents was published in the Daily Olympian on August 8, 1999. Notices were also sent out to the people on the mailing list.

A public comment period was held from August 6 through September 6, 1999. In addition a public hearing was conducted on August 17, 1999, where the results of the RI/FS and Proposed Plan was presented and questions and comments taken from the public. The comments received were generally supportive of the Proposed Plan. The response to comments received during the comment period is included in the Responsiveness Summary, which is part of this ROD. The preferred remedial action alternative presented in the proposed plan was modified in response to the public comments received, as described in Section 9.2.9.

This decision document presents the selected remedial action for the Palermo Wellfield Site chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. The decision for this site is based on the Administrative Record.

The primary documents pertaining to this investigation can be reviewed at the following locations:

Tumwater Timberland Public Library
7023 New Market Street
Tumwater, Washington

FINAL RECORD OF DECISION
Palermo Wellfield Superfund Site
RAC, EPA Region 10
Work Assignment No. 54-49-OJCO

Section 4.0
Date: 10/99
Page 4-2

Superfund Records Center
Environmental Protection Agency Region 10
1200 Sixth Avenue
Seattle, WA

5.0 SUMMARY OF SITE CHARACTERISTICS

This section summarizes regional characteristics and site conditions, including discussions of the ecological setting, climate, surface water patterns, geology, and hydrogeology, as well as the nature and extent of chemicals of concern at the Palermo Wellfield Superfund Site.

5.1 ECOLOGICAL SETTING

5.1.1 Flora and Fauna

The study area is situated within the terrestrial zone of western hemlock (*Tsuga heterophylla*), a vegetation zone that is common in British Columbia, the Olympic Peninsula, the coastal ranges, the Puget Sound Trough, and the Cascade physiographic provinces in western Washington. Without major land alteration, the Palermo Wellfield Superfund Site would have been typical of this zone. The development that has taken place in the vicinity of the wellfield has altered the natural vegetation of the site, making it less likely that many wildlife species would use the area. Vegetation in the area includes Douglas fir, bigleaf maple, Pacific madrona, vine maple, western hemlock, and western red cedar. Understory growth includes sword fern, kinnikinnick, salal, Oregon grape, and rhododendron. The residential areas also include numerous ornamental plants.

Terrestrial wildlife found within the area includes deer, black bear, lynx, fox, coyote, cougar, and a large variety of birds, small rodents, reptiles, and amphibians. Year-round resident birds include Steller's jay, starling, flicker, crow, black-capped chickadee, robin, and junco. A number of migratory bird species pass through the region during spring and fall migrations.

The lower Deschutes River, approximately 1/4 mile from the Palermo Wellfield, is a major spawning reach for salmon using this river system. Nearshore plant cover provides habitats for the spawning of both anadromous and freshwater fish species. Chinook and coho salmon spawn in the Deschutes River system along with other commercial and recreationally important fish species, such as sea run cutthroat trout, steelhead trout, and resident rainbow trout. In addition, areas of the Deschutes River provide habitat for the Olympic mudminnow, which is a candidate for a Washington State species of concern designation. A variety of birds (e.g., duck, kingfisher, herons) and mammals (e.g., raccoon, muskrat, mink) live and forage on the river.

Within the State of Washington, species of concern include those species listed as State Endangered, State Threatened, State Sensitive or State Candidate, as well as federally listed or proposed for listing species by the U.S. Fish and Wildlife Service and the National Marine

Fisheries Service. Fish species of concern known to be present in the Deschutes River are chinook salmon (*Oncorhynchus tshawytscha*), a federal threatened and Washington candidate species; and the Olympic mudminnow (*Novumbra hubbsi*), a Washington candidate species which has been recommended for sensitive status. Chinook salmon stocks in the Deschutes River have not been extensively studied. They are believed to be primarily of hatchery origin, however, the presence of native fish cannot be ruled out.

5.1.2 Climate

The Palermo Wellfield Superfund Site is located in the extreme southern portion of the Puget Sound Trough. The climate is characterized by relatively dry summers and wet spring, fall, and winter seasons, with prevailing winds from the north-northeast at a mean speed of 6.7 miles per hour. Monthly precipitation averages range from 8 inches in January, November, and December to less than 1 inch in July. The average annual precipitation is approximately 50 inches per year.

The mean daily summer maximum temperature ranges from approximately 71 degrees Fahrenheit (°F) in June to 77°F in August with the mean daily summer minimum temperature ranging from approximately 47 to 50°F. The mean daily winter maximum temperature ranges from approximately 44°F in December to 49°F in February with the mean daily winter minimum temperature ranging from 31 to 33°F.

Precipitation was unusually high in 1997 and 1998. The annual precipitation for 1997 was 64.83 inches or almost 15 inches above the annualized average. Rainfall from November 1998 through January 1999 was 40.2 inches. This breaks the previous 3-month total record of 35.52 inches recorded from 1954 to 1955. This above-average rainfall may or may not influence local groundwater flow patterns. Depth to groundwater has decreased (groundwater surface elevation increased) from 2 to 5 feet in 1998 compared to the 1995 data. This general decrease in depth of groundwater beneath the ground surface is observed across the site.

5.1.3 Floodplains, Wetlands, and Historic Properties

The floodplain of the Deschutes River, as designated by the Federal Emergency Management Agency, extends from the River westward to include the Tumwater Municipal Golf Course and approximately the eastern-most quarter of the Palermo neighborhood. Portions of the remedy selected by this ROD (specifically the aerated lagoon at the golf course described in Section 8.2.8) will be constructed within this floodplain.

Much of the land area surrounding the Palermo neighborhood exhibits plant species, topography, and saturated soil conditions indicative of wetland environments. The area south of the neighborhood appears as a designated wetland on published maps. Portions of the remedy

selected in this ROD (specifically the surface water collection and treatment structures described in Section 8) will be constructed within these wetlands and will have some long-term effect on the shallow groundwater that creates a wetland environment.

No historic properties listed on or eligible for listing on the National Register of Historic Places are located within the Palermo Wellfield Superfund Site.

5.2 GEOLOGIC CONDITIONS

The geologic conditions at the site are summarized on a geologic cross section of the area, presented as Figure 5-2 (Figure 5-1 shows the cross section location).

Geology of the area consists of Deschutes River fluvial deposits cutting into older glacial deposits. The glacial sediments consist of the Vashon Drift, which was deposited during the advance and retreat of the Puget Lobe of the Cordilleran Ice Sheet during the last glacial advance in Puget Sound. Glacial deposits are flat-lying in the uplands area with localized relief comprising Tertiary basalt or marine sandstone.

Fluvial sediments in the valley are unconsolidated sands and gravels with minor silty interbeds. Fluvial deposits range in thickness from approximately 100 feet to greater than 186 feet. The Palermo Wellfield wells are completed within these fluvial deposits.

Glacial advance and retreat has occurred, resulting in three distinct unconsolidated formations in the area: the Vashon Drift, Kitsap Formation, and Penultimate Drift (Pre-Vashon Drift). Upland deposits west of the valley are recessional outwash deposits from the Vashon Drift. These deposits are reported to be predominantly sand.

Vashon till, a dense, poorly sorted sand with variable amounts of silt and gravel, is found beneath the recessional outwash in the southwestern portion of the Palermo Valley. The till is reported to be absent in the uplands area west of the Palermo Wellfield. The Kitsap Formation is identified as an interglacial deposit of fine-grained material resting below the Vashon Drift. A blue clay was identified in the drill log for City of Tumwater well 5 at a depth of 120 feet below ground surface (bgs), which may be part of the Kitsap Formation. However, fine-grained deposits were not identified in boring ES-10 approximately 600 feet west of well 5 to a depth of 132 feet bgs, indicating that the interglacial deposits are not laterally continuous or were deposited on an undulating surface. The Penultimate Drift consists of glacial sediments deposited prior to the interglacial deposition represented by the Kitsap Formation.

Bedrock in the study area is described as Tertiary sediments and basalt. Basalt has been identified in a boring at the Olympia Brewery at a depth of approximately 300 feet bgs and at depths greater than 350 feet bgs at other locations within the Deschutes River Valley. Bedrock is exposed in the uplands, west of the Palermo Wellfield.

5.3 HYDROGEOLOGIC CONDITIONS

The hydrogeologic conditions beneath the site are depicted on a cross-section included as Figure 5-2 (Figure 5-1 shows the location of this cross-section). Two aquifer systems are reported in the study area. The uppermost aquifer system is the Deschutes River Alluvium and the Vashon Drift (including the Vashon Till and Vashon recessional outwash shown in Figure 5-2). This system is considered to be unconfined (Vashon Drift in the uplands) to semiconfined (Deschutes River Alluvium in the valley). The Palermo Wellfield wells are completed within the Deschutes River Alluvium at depths ranging from 70 to 110 feet bgs. Static water levels within the Palermo Wellfield wells are generally less than 10 feet bgs. The difference in the depth to the screened water bearing zone and the depth to water in the completed wells suggests semiconfined conditions in the valley. Groundwater surface elevations in the uplands are comparable to elevations in the valley. This suggests that the Vashon Drift in the uplands is unconfined and hydraulically linked to the Deschutes River Alluvium. Groundwater flow across the study area is reported to be to the east with some radial flow from Barnes Lake.

The lower aquifer is identified as the Penultimate Drift, located beneath the interglacial, fine-grained deposits of the Kitsap Formation. The Kitsap Formation is reportedly a confining layer to the Penultimate Drift. Static water levels for wells completed within the Penultimate Drift have been reported ranging from 100 feet bgs to hydraulic heads above the ground surface. The brewery wells near the Palermo Wellfield appear to be completed within the Kitsap Formation and the Penultimate Drift, at depths of 100 to 175 feet bgs.

Depth to water in the upland site wells appears to be approximately 10 to 55 feet bgs. Depth to water in the valley site wells appears to be approximately 4 to 8 feet bgs with scattered artesian conditions observed near the base of the bluff. The groundwater flow velocity at the site ranges from 0.48 to 0.77 feet per day.

5.4 SAMPLING OF SOIL, GROUNDWATER, AND SURFACE WATER

Investigations conducted prior to performance of the formal RI resulted in soil and groundwater sampling at approximately 109 GeoProbe locations, and the installation of 11 groundwater monitoring wells, 6 vapor monitoring wells, and 6 vapor extraction wells. These studies also

included air screening and surface water sampling in the vicinity of homes at the base of the Palermo Bluff. RI field activities included soil and groundwater sampling at 37 GeoProbe locations and 3 soil boring locations, installation of 12 groundwater monitoring wells, collection of surface water samples at 19 locations, and quarterly sampling of 23 monitoring wells.

5.5 NATURE AND EXTENT OF CHEMICALS

The nature and extent of contamination are summarized in the following subsections. Additional information is included in the RI.

5.5.1 Identified Chemicals

Groundwater

During the sampling efforts described in Section 5.4, the chemicals listed below were detected in groundwater samples. The list of chemicals below is in decreasing order of detection frequency:

- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- cis-1,2-Dichloroethene (c-DCE)
- BTEX (total)
- Toluene
- 1,1,1-Trichloroethane
- Xylenes
- Xylenes (total)
- m,p-Xylene
- trans-1,2-Dichloroethene
- 2-Butanone
- Carbon disulfide
- Vinyl chloride
- o-Xylene
- Chloroform
- 1,2,4-Trimethylbenzene
- Ethylbenzene
- 1,3,5-Trimethylbenzene
- Chloromethane
- 1,1-Dichloroethene
- 2-Hexanone
- 4-Methyl-2-pentanone

- Acetone
- 1,2-Dichloropropane
- 2-Chlorotoluene
- 4-Isopropyltoluene
- Bromodichloromethane
- Chloroethane
- Dibromochloromethane
- n-Butylbenzene
- n-Propylbenzene
- sec-Butylbenzene

Twenty-two of the 32 detected chemicals in groundwater were detected in less than 10 analyzed samples. PCE and TCE were the most frequently detected analytes in the groundwater samples. PCE was detected in 287 of the 690 (42%) samples with concentrations ranging from 0.03 to 949 $\mu\text{g/L}$ (average 64.2 $\mu\text{g/L}$). TCE was detected in 282 of the 704 (40%) analyzed groundwater samples with concentrations ranging from 0.07 to 824 $\mu\text{g/L}$ (average 50.7 $\mu\text{g/L}$).

Surface Water

Three chemicals were detected in the surface water samples collected at the site. These samples were collected from the ponded surface water that results from seepage of shallow groundwater of the base of the Palermo Bluff. Samples were collected from standing water at the base of the bluff, water in crawlspace sumps in some homes, and water in stormwater conveyance ditches and piping outfalls in the Palermo neighborhood. TCE was detected in 13 of the 22 (59%) samples at concentrations ranging from 0.3 $\mu\text{g/L}$ to 115 $\mu\text{g/L}$ (22.6 $\mu\text{g/L}$ average). PCE was detected in 11 of the 22 (50%) samples at concentrations ranging from 0.26 $\mu\text{g/L}$ to 102 $\mu\text{g/L}$ (24.1 $\mu\text{g/L}$ average). C-DCE was detected in 5 of the 22 (23%) samples.

Soil

Twenty-one chemicals were detected in the soil samples collected at the site. The detected chemicals are listed below in decreasing order of detection frequency:

- Tetrachloroethene
- Trichloroethene
- 4-Methyl-2-pentanone
- Acetone
- 2-Hexanone
- Methylene chloride
- Chloroform

- 1,1,1-Trichloroethane
- Bromoform
- Vinyl chloride
- 2-Butanone
- Toluene
- 1,2,4-Trimethylbenzene
- Benzene
- Chloromethane
- 1,2-Dichloroethene
- 1,3,5-Trimethylbenzene
- Chloroethane
- Dichlorofluoromethane
- Xylenes
- trans-1,2-Dichloroethene

Only 6 of the 21 these chemicals were detected in more than 10 analyzed samples. PCE and TCE were by far the most frequently detected analytes in the soil samples. PCE was detected in 167 of the 472 (35%) samples with concentrations ranging from 0.00003 to 258 mg/kg (average 3.25 mg/kg). TCE was detected in 54 of the 456 (12%) samples with concentrations ranging from 0.00004 to 1.48 mg/kg (average 0.11 mg/kg).

5.5.2 Chemicals of Concern

Of the chemicals identified in soil, groundwater and surface water at the site (Section 5.5.1), PCE and TCE were identified as the only COCs by the baseline risk assessment (Section 6.0). PCE and TCE were identified as the COCs by a screening process that compares the maximum chemical concentrations found to one-tenth of the EPA's screening toxicity values for those chemicals. All compounds were detected at concentrations less than 1/10 of screening values and therefore were not identified as COCs. This process is described in more detail in the human health risk assessment (Section 6.0). PCE and TCE were identified as COCs in groundwater and surface water. None of the chemicals found in soil at the site were found to pose a direct risk to human health and the environment. However, PCE and TCE were found to be COCs in soil because of the potential for these compounds to act as residual sources of groundwater contamination.

5.5.3 Source Area of Contamination

The extent of contamination is depicted in cross-sections included as Figures 5-4 and 5-5. (Figure 5-3 shows the locations of these cross-sections.)

Soil contamination has been identified in three primary locations (Figure 2-1): Southgate Dry Cleaners in the Southgate Mall; Brewery City Pizza located across Capitol Boulevard to the east of Southgate Mall; and the Chevron service station located northeast of the intersection of Trospers Road and Second Avenue. Some of this soil contamination (such as that identified beneath the Brewery City Pizza) has probably resulted from partitioning of contaminants from groundwater. Groundwater beneath Brewery City Pizza, which is directly downgradient from Southgate Dry Cleaners, exhibits high COC concentrations. Soil contamination at Brewery City Pizza could have resulted from volatilization of COCs from groundwater, and subsequent adsorption onto soil particles. Smaller areas of contaminated soil have been identified at the WDOT MTL and the WDOT Maintenance Facility. Minor quantities of PCE in soil have also been identified at Poages Towing and other locations within the study area.

The lateral distribution of volatile organics in groundwater consists generally of a narrow, elongate plume with the long axis oriented west-southwest to east-northeast. The lateral and vertical distribution of PCE and TCE in groundwater beneath Southgate implies two substantially distinct plumes, with PCE overlying TCE, and a zone of commingling and/or transformation between the two. TCE can be a breakdown product of PCE. The PCE plume exhibits a smaller lateral extent, which is generally within the lateral limits of the TCE plume. In the east-west direction, the area of contamination extends from the intersection of Trospers Road and Second Avenue in the west to the Palermo Wellfield in the east. At its widest point in the north-south direction, the area of contamination extends from the Capitol 5000 Building in the north to the southern end of the Southgate Mall in the south (Figure 2-1).

The highest PCE concentrations in groundwater were detected in samples collected from the Southgate Mall area and immediately downgradient at Brewery City Pizza. The highest PCE concentrations in groundwater were detected in samples from 35 to 75 feet bgs.

The highest TCE concentrations in groundwater were detected in samples from two locations. The first location was in the extreme northern portion of the Southgate Mall property, directly downgradient of the WDOT MTL. The other location was a monitoring well downgradient of Southgate Mall.

Southgate Dry Cleaners is the primary source of PCE in soil in the Southgate Mall area, and in groundwater that extends east to the Palermo neighborhood. Evidence for Southgate Dry Cleaners being a source of PCE includes the presence of an abandoned dry well or sump, high concentrations of PCE in soil beneath the dry cleaners from the ground surface to the groundwater surface, and high concentrations of PCE in groundwater. Southgate Dry Cleaners may also be a source of TCE observed in the area, because PCE is apparently being transformed into TCE. This occurs through the breakdown of PCE to TCE by a biologic process involving naturally-occurring bacteria. The WDOT MTL is a documented source of TCE in soil and

groundwater beneath this facility. Evidence for the Chevron station property being a source of TCE contamination includes the presence of TCE in soil beneath the property from ground surface to two groundwater surface, high concentrations of TCE in groundwater beneath the property, and the use of the property as a service station. Groundwater modeling indicates that releases of TCE at the WDOT MTL and Chevron have acted as sources for contamination eastward to the Palermo Wellfield.

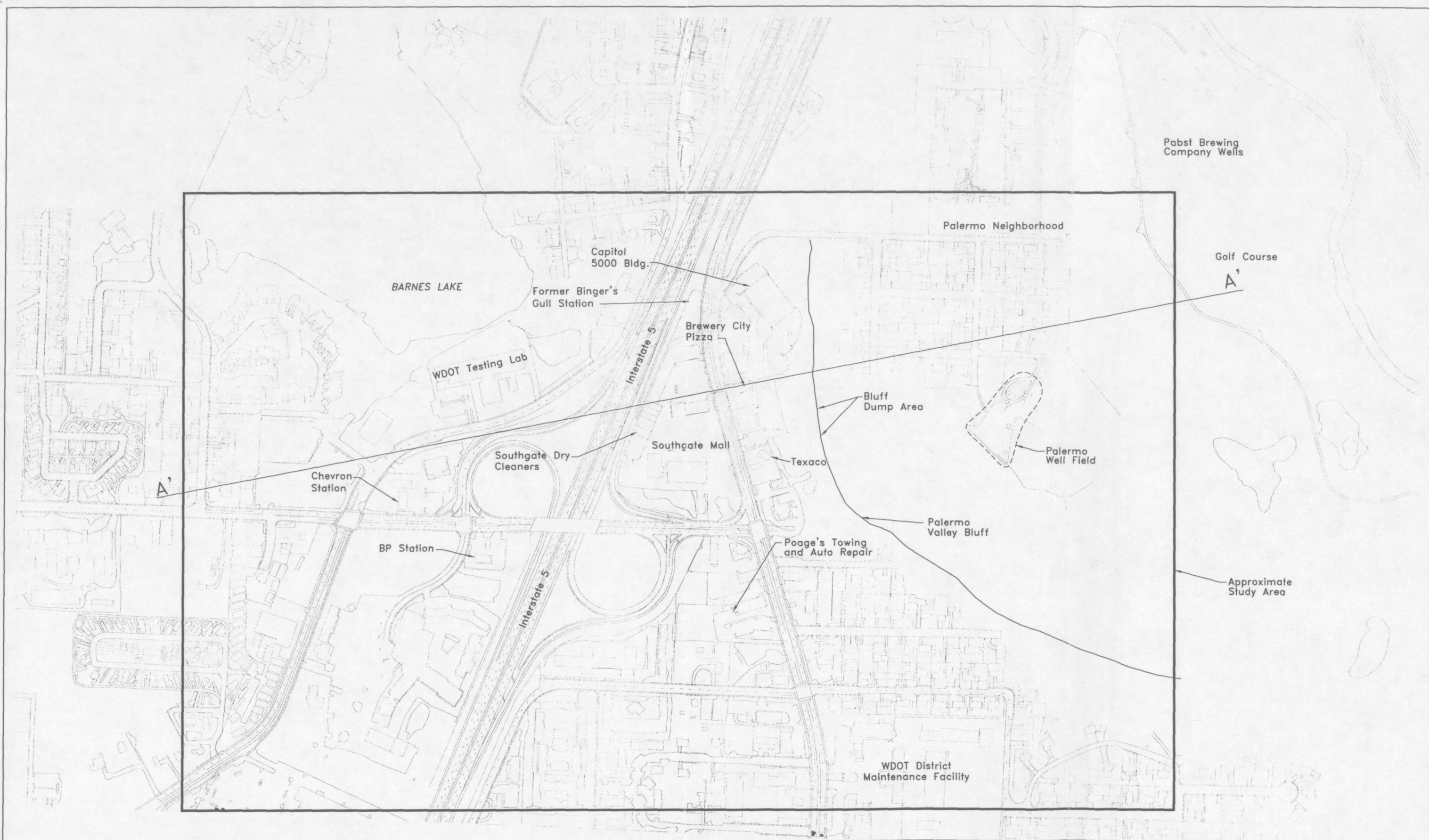
Groundwater daylights at the base of the Palermo Bluff (Figure 2-1), resulting in seeps and ponded surface water in the area of the residences west of Rainier Avenue. The extent of ponded surface water containing COCs varies seasonally. At a maximum, surface water is present from a drainage ditch located west of the residences; eastward through the yards of the residences and in the crawlspaces of the residences; and into the western side of Rainier Avenue. In the north-south direction, ponded surface water can be present along the entire length of Rainier Avenue, from O Street to M Street (Figure 2-1).


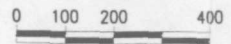
5.6 FATE AND TRANSPORT OF CHEMICALS

PCE and TCE in groundwater beneath the study area have migrated from the source areas to the east-northeast, in the direction of groundwater flow. The average retarded contaminant velocities for PCE and TCE at the site range from 0.01 to 0.64 feet per day for PCE and 0.05 to 0.77 feet per day for TCE. Groundwater modeling indicates that natural groundwater flow would have carried the contaminants north of the Palermo Wellfield toward the Pabst Brewery Wellfield and the Deschutes River if groundwater pumping were not taking place at the Palermo Wellfield. The Palermo Wellfield captured the plume, however, by changing the local groundwater flow direction. It appears that continued pumping of the Palermo Wellfield wells at flow rates similar to the current flow rates will result in continued complete capture of the plume, preventing migration of PCE and TCE northeast of the Palermo Wellfield.

Natural attenuation of PCE and TCE at the site was evaluated during the RI. Physical natural attenuation (dilution, dispersion, and adsorption) appears to be the dominant process at this time. Very limited anaerobic biodegradation in the valley, near the Chevron station and the WDOT MTL, and downgradient of Southgate is suggested by very limited areas of depressed levels of dissolved oxygen and Eh, and sporadic detections of the degradation product cis-1,2-dichloroethene (DCE). Samples analyzed for vinyl chloride using low detection level methods such as selected ion monitoring during the fourth quarterly round of groundwater monitoring for the RI showed no detectable concentrations. The absence of widespread anaerobic conditions and limited presence of chemicals (iron, nitrate, sulfate, etc.) that would enhance biodegradation argue against the widespread transformation of PCE and TCE to daughter chemicals.

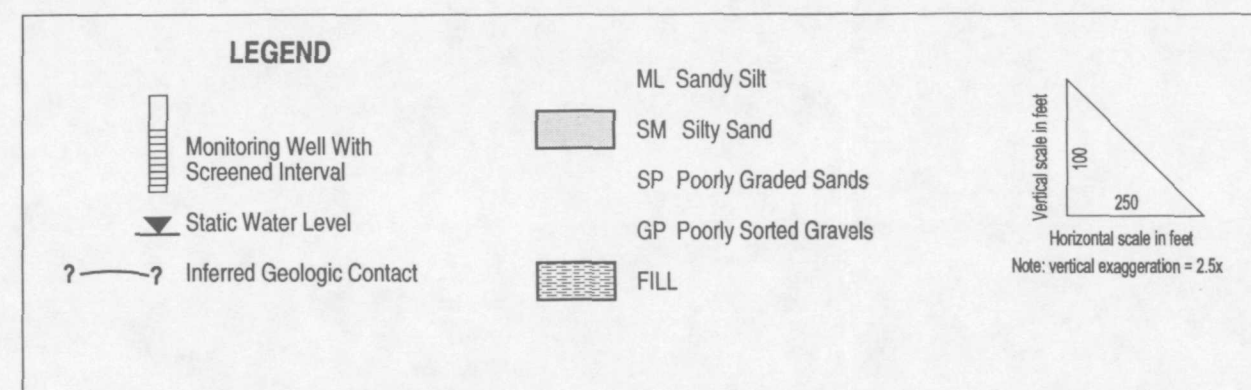
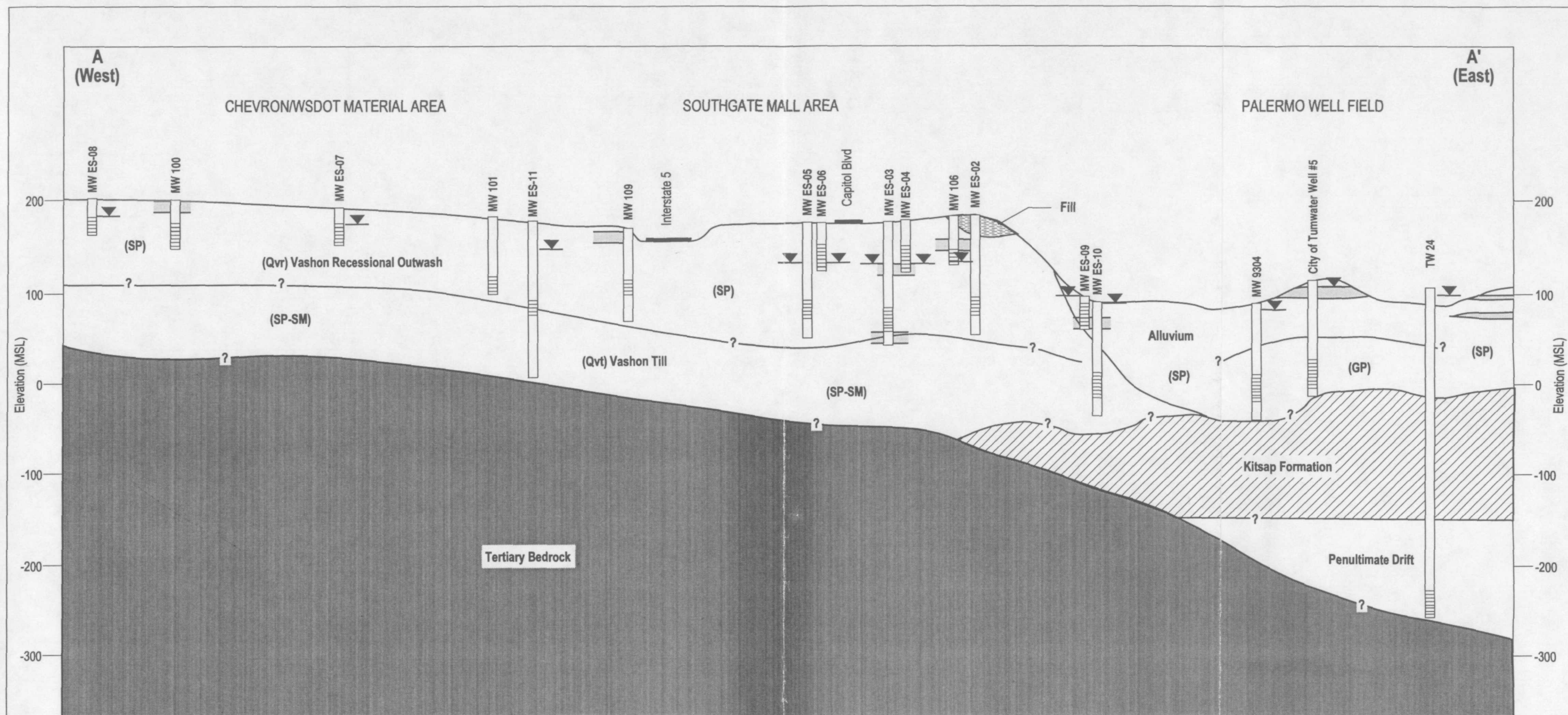
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Palermo Wellfield Superfund Site Tumwater, WA ARCS EPA REGION 10	  SCALE IN FEET

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Figure 5-1
Geologic Cross-Section Location



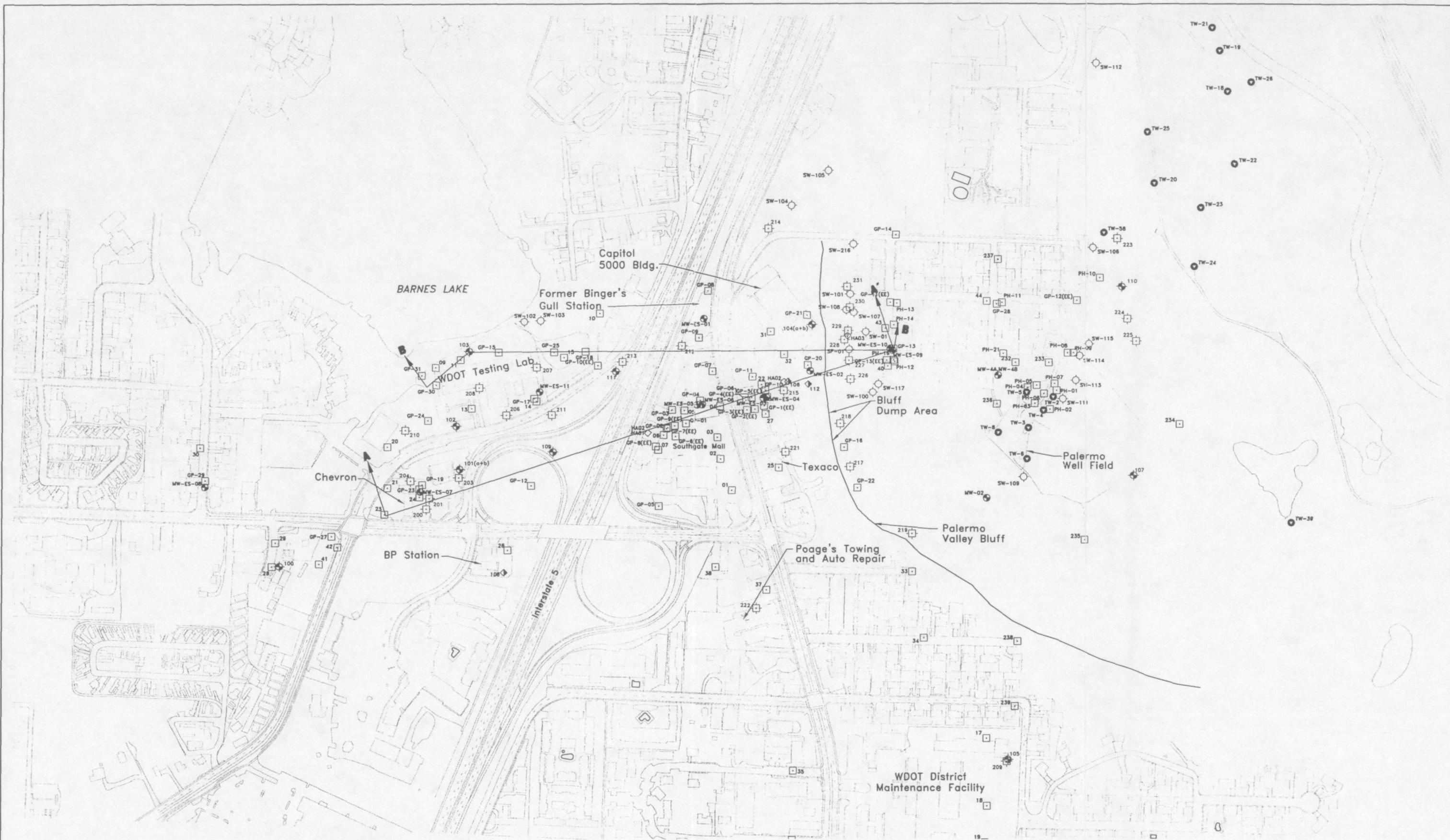
EPA
REGION 10

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Palermo Wellfield Superfund Site
RECORD OF DECISION

Figure 5-2
Geologic Cross-Section A-A'

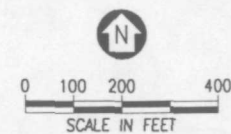
Source: Weston 1996/URSG 1998



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| SP-01 | HA-01 | 112 |
| GP-01 | MW-01 | |

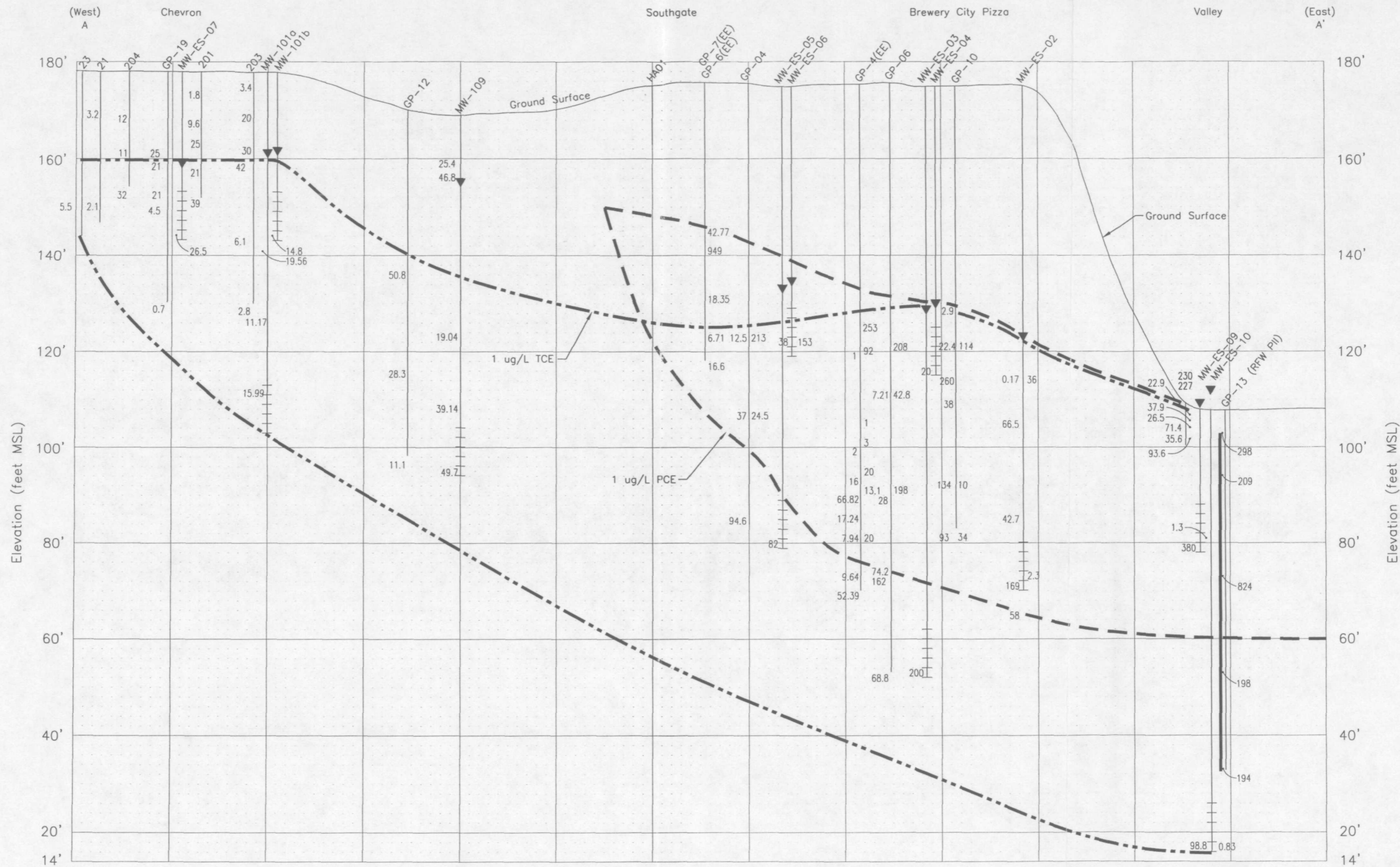
Palermo Wellfield Superfund Site
 Tumwater, WA
 ARCS EPA
 REGION 10



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Figure 5-3
Contaminant Distribution
Cross-Section Location

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Screen Interval

Groundwater Surface
 May 1998

Key

Soil (ug/kg) TCE
 Water (ug/l) TCE PCE
 Approximate Vertical Extent

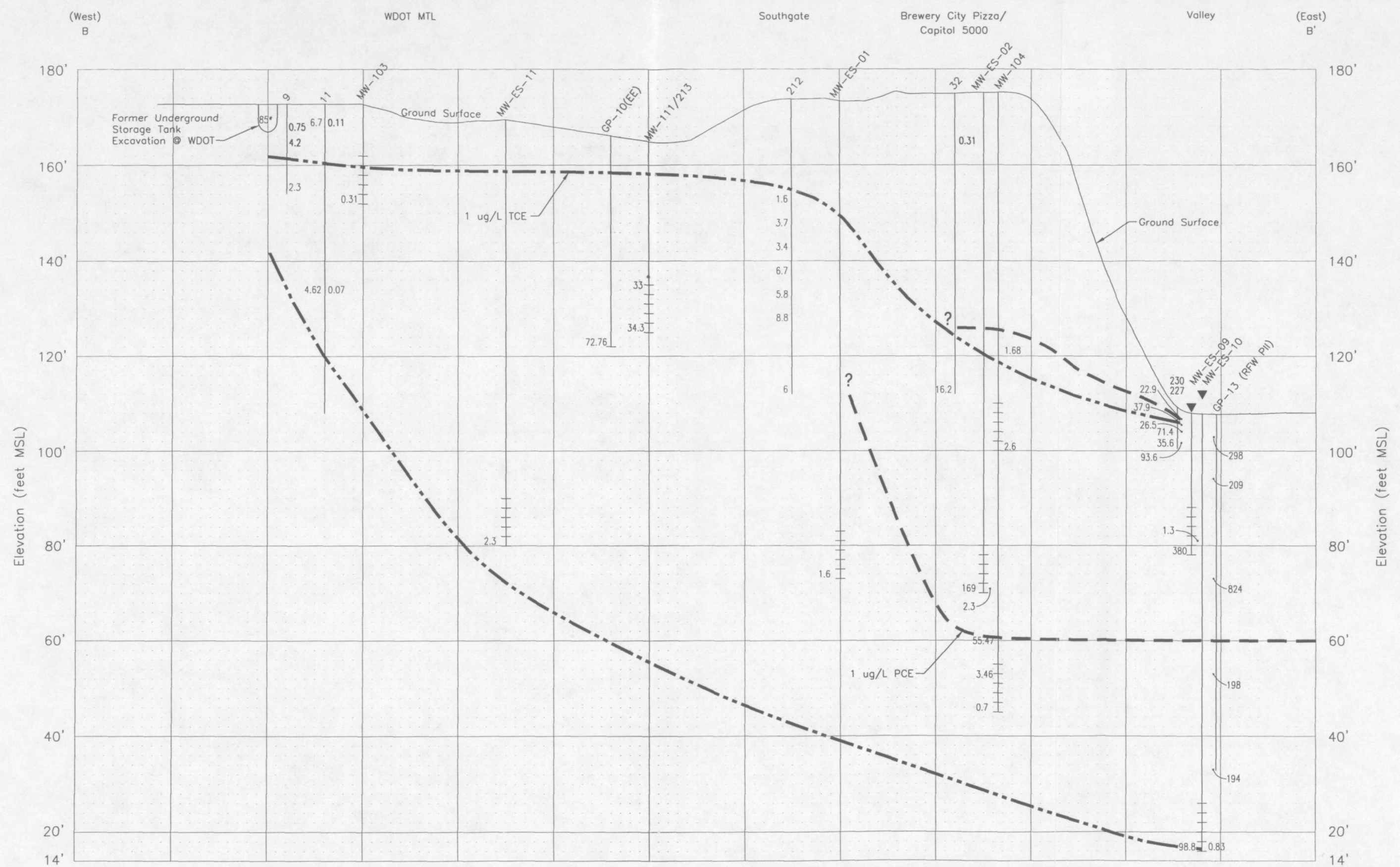
Palermo Wellfield Superfund Site
 Tumwater, WA
 ARCS EPA
 REGION 10

Vertical Scale: 1"=20'
 Horizontal Scale: 1"=200'

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Figure 5-4
Section A-A'
Showing Select PCE and TCE Soil &
Groundwater Analytical Results

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- Screen Interval
- Groundwater Surface May 1998
- Key
 - Soil (ug/kg) TCE PCE
 - Water (ug/l) TCE PCE
 - Approximate Vertical Extent

*Emcon
1996

Palermo Wellfield Superfund Site
Tumwater, WA
ARCS EPA
REGION 10

Vertical Scale: 1"=20'
Horizontal Scale: 1"=200'

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Figure 5-5
Section B-B'
Showing Select PCE and TCE Soil and
Groundwater Analytical Results

6.0 SUMMARY OF SITE RISKS

6.1 INTRODUCTION

A baseline risk assessment was conducted to evaluate the current and future human health and ecological risks associated with chemicals in soil, groundwater, and surface water in the vicinity of the Palermo Wellfield. The assessment serves as a baseline to indicate risks that could exist if no action were taken, and takes into consideration potential risks if existing residential use patterns shift in the future, such as impacted groundwater used as tap water in the homes. The results of the risk assessment are used in evaluating whether remedial action is needed.

The risk assessment followed the basic guidelines defined by the EPA and current scientific data. A risk assessment evaluates the likelihood of adverse effects occurring in human or ecological populations potentially exposed to chemicals released in the environment. Risk assessments are not intended to predict the actual risk of an individual. Instead, they provide upper-bound and central tendency estimates of risk with an adequate margin of safety, according to EPA guidelines, for the protection of virtually all receptors that may potentially come into contact with chemicals at the site.

6.2 HUMAN HEALTH RISK ASSESSMENT

The human health risk assessment in the RI characterized risks to humans, both current and future, from exposure to chemical contaminants detected at the site. Exposures to residents in potential contact with chemicals in surface water along Rainier Avenue in Tumwater and exposures to residents in contact with chemicals in the groundwater plume were evaluated. Current residential exposure to surface water was evaluated for children between the ages of 4 through 11 playing in the surface water ditch that runs behind the homes located along Rainier Avenue. Residential exposure to surface water was also evaluated for adults and children residing at the site for over a 30-year period. These residents were evaluated for inhalation exposures to indoor air volatiles emitted from groundwater seepage as surface water present in the belowground crawlspaces.

Residential exposure to groundwater was evaluated for adults assuming they would use the impacted groundwater as their tap water source in their homes at some point in the future. No residents are currently drinking impacted groundwater. The water supply wells with detected chemicals in the Palermo Wellfield were removed from service in 1993 and air-strippers were recently constructed that remove all chemicals of concern from the drinking water.

In summary, risks were calculated for three exposure scenarios: 1) children (4 to 11 years old) currently playing in the drainage ditch containing impacted groundwater seepage as surface water; 2) children and adults (over a 30-year period) currently inhaling indoor air volatiles emitted from groundwater seepage in crawlspaces beneath the residences; and 3) adult residents (over a 30-year period) in contact with groundwater during all household use of tap water in the future.

In addition, a screening of risks from exposure to subsurface soils was also conducted, since future site redevelopment plans are uncertain. The risks from combined incidental ingestion, dermal contact, and inhalation exposures to chemicals in subsurface soil were calculated for the following three potential future receptors: 1) commercial (occupational) worker employed on-site; 2) short-term construction worker for 12 months (5 days per week); 3) on-site resident for a duration of 30 years (worst-case exposure scenario). The screening results indicated that the chemicals of concern in subsurface soil are unlikely to be a health concern even under a worst-case future residential scenario. Furthermore, the current and reasonably anticipated land use assumption for this site is likely commercial.

The primary components of the risk assessment include data evaluation, exposure assessment, toxicity assessment, and risk characterization, which are discussed in the following subsections.

6.2.1 Data Evaluation

The initial step in the risk assessment reviewed the available sampling results for each affected environmental medium (e.g., soil, air, water) to identify a list of chemicals, referred to as chemicals of concern (COCs), to be carried through the remainder of the risk assessment. The COCs were identified by conservatively comparing the maximum chemical concentrations in the different media to one-tenth the screening toxicity values (STVs) found in the EPA Region 9 Preliminary Remedial Goal (PRG) Tables.

PCE and TCE were the only COCs selected in groundwater and surface water to be evaluated further in the risk assessment, since they exceeded their risk-based STVs. No COCs were selected for soil. Other chemicals did exceed the conservative STVs; however, they were eliminated from further evaluation in the risk assessment due to the following reasons:

- Low frequency of detection during sampling
- Infrequency of exceedances over STVs
- Small magnitude of exceedance over STVs
- Lack of historical association with known sources

- Possibility of being a laboratory contaminant
- Lack of exceedance of applicable or relevant and appropriate requirements (ARARs)
- Chemical identified as an essential nutrient, which are generally considered nontoxic
- Coverage with asphalt/concrete or a building footprint

A list of the COCs identified for groundwater and surface water at the Palermo Wellfield site are presented in Tables 6-1 and 6-2 along with the exposure point concentrations (Section 6.2.2).

6.2.2 Exposure Assessment

An exposure assessment typically evaluates sources, pathways, receptors, exposure duration and frequency, and routes of exposure to assess total human exposure to the COCs at the site. This assessment identified the populations potentially exposed to chemicals at the site, the means by which exposure occurs, and the amount of intake from each exposure media.

The result of this process is a calculated daily intake per body weight for each medium of concern. The daily intake rate per body weight (intake or administered dose) combines exposure parameters for the receptors of concern (e.g., contact rates, exposure frequency and duration) with chemical-specific toxicity criteria and exposure point concentrations (EPCs) for the media of concern to arrive at an estimate of health risk.

To calculate human intake of chemicals, EPCs must be estimated. EPCs are those concentrations of each chemical to which an individual may potentially be exposed for each medium at the site. EPCs were developed from analytical data obtained during the investigation. EPCs were calculated for both average (central tendency) exposures and reasonable maximum exposures (RME or upper-bound) at the site.

The RME is an estimate of the highest exposure that is reasonably expected to occur at the site and may overestimate the actual risk for the majority of the population. The RME concentration was calculated as the lesser of the maximum detected concentration or the 95 percent confidence limit on the arithmetic mean.

The central tendency (CT) estimate is defined as the average of typical exposures for that population. Calculations of a more "typical" (central tendency or average) exposure are designed to approximate more average exposures at the site. Each average exposure point concentration

was calculated as an arithmetic average of the chemical results for a particular medium using half the sample quantitation limit for non-detected chemicals. The average exposure scenario was evaluated to allow comparison with the RME scenario. Tables 6-1 and 6-2 present the COCs and their EPCs in each groundwater well (including all site data combined) and in surface water, respectively.

The exposure parameters used in the risk assessment to calculate the intake of site chemicals in terms of a daily dose per body weight are presented in Table 6-3.

For the risk assessment, the population of concern for exposures to groundwater is hypothetical residents (adults over an exposure period of 30 years) using the impacted groundwater as a tap water source in the future. The exposure duration is based on the assumption that residents are born at the site and remain there for 30 years. Currently, residents are not using the impacted groundwater as a water supply source in their households. The population of concern for exposures to surface water is also residents, in particular, elementary school-age children (4 through 11 years old). Both adults and children (for an exposure period of 30 years) are considered the primary concern for evaluating exposures to air concentrations of chemicals that may have originated from groundwater seeping into crawlspaces when the water table is high.

In summary, the following pathways and routes of exposure were quantitatively evaluated in the risk assessment:

- Residential exposures during all indoor use of tap water by ingestion, inhalation, and dermal contact with groundwater
- Exposures to children (4 to 11 years old) playing in the drainage ditch by ingestion of, and dermal contact with, impacted groundwater seepage (as surface water)
- Exposures to both adults and children (over a 30-year period) while inside their homes by inhalation of indoor air concentrations emitted from groundwater seepage (as surface water) found in the crawlspaces

Evaluating these exposure scenarios will be protective for other, short-time visitors to the site. Evaluating adult exposures to groundwater during all indoor use of tap water will likely be protective of children, since carcinogenic risks were estimated using lifetime exposures and the noncarcinogenic hazards were calculated using an exposure duration of 30 years. A noncarcinogenic hazard was also calculated specifically for children from exposure to groundwater via all three exposure pathways mentioned above.

6.2.3 Toxicity Assessment

The toxicity assessment qualitatively summarized the carcinogenic and noncarcinogenic effects associated with the COCs and provided toxicity values that were used to calculate the dose-response relationship. The summary intake factors calculated in the exposure assessment section were combined with toxicity criteria and chemical concentrations to estimate a cancer risk or a noncancer hazard. The toxicity criteria describe the quantitative relationship between the dose of a chemical and the magnitude of the toxic response.

Key dose-response criteria are EPA slope factors (SFs) for assessing cancer risks and EPA-verified reference dose (RfD) values for evaluating noncarcinogenic effects. Toxicity values are derived from either epidemiological or animal studies, to which uncertainty factors are applied. These uncertainty factors account for variability among individuals, as well as for the use of animal data to predict effects on humans. Sources of these criteria are from the EPA online database Integrated Risk Information System (IRIS); the EPA Region 9 PRG Tables; and the EPA National Center for Environmental Assessment (NCEA): Superfund Technical Support Center.

The carcinogenic SF is multiplied by the estimated daily intake rate of a potential carcinogen to provide an upper-bound estimate of the probability of a response (the probability of an individual developing cancer) per unit intake of a chemical over a lifetime. SFs are expressed in units of mg/kg-day^{-1} . The upper-bound estimate reflects the conservative estimate of risks calculated from the SF. This approach makes underestimation of the cancer risk unlikely.

The chronic RfD, expressed in units of mg/kg-day , is an estimated daily chemical intake rate for the human population, including sensitive subgroups, that appears to be without appreciable risk of noncarcinogenic effects if ingested over a lifetime. Estimated intakes of COCs are compared with their RfDs to assess the noncarcinogenic hazards.

PCE. The slope factors and reference doses for PCE were not available on the EPA IRIS database, though they were reported in an NCEA paper, and in the EPA Region 9 Preliminary Remedial Goal (PRG) Tables. The oral SF as listed was $5.2 \times 10^{-2} (\text{mg/kg-d})^{-1}$ and the inhalation SF was $2.0 \times 10^{-3} (\text{mg/kg-d})^{-1}$. The IRIS database is typically selected as the primary source of toxicity criteria when evaluating health risks or setting health-based cleanup goals because of the extensive research effort and scientific peer review. However, NCEA may serve as an adequate source if toxicity criteria are not available in IRIS.

The chronic oral RfD listed was $1.0 \times 10^{-2} \text{ mg/kg-day}$ and, assuming a 100 percent oral-to-dermal adjustment factor (as for carcinogenic effects), the dermal RfD value is the same as the oral RfD

value. The inhalation Rfd of 0.114 mg/kg-day used in the risk assessment was reported in the EPA Region 9 PRG Tables.

TCE. The slope factors for TCE were also not available on the EPA IRIS database, though they were reported in an NCEA paper and in the EPA Region 9 PRG Tables. The oral SF as listed was $1.1 \times 10^{-2} \text{ (mg/kg-d)}^{-1}$ and the inhalation SF was $6.0 \times 10^{-3} \text{ (mg/kg-d)}^{-1}$. Using a 100 percent oral-to-dermal adjustment factor, the dermal SF is the same as the oral SF of $1.1 \times 10^{-2} \text{ (mg/kg-d)}^{-1}$.

The chronic oral Rfd of $6.0 \times 10^{-3} \text{ mg/kg-day}$ used in the risk assessment was listed in the EPA Region 9 PRG Tables and, assuming a 100 percent oral-to-dermal adjustment factor (as for PCE), the dermal Rfd value is the same as the oral Rfd value. The inhalation Rfd of $6.0 \times 10^{-3} \text{ mg/kg-day}$ used in the risk assessment was also reported in the EPA Region 9 PRG Tables.

6.2.4 Risk Characterization

The risk characterization process was performed to estimate the likelihood, incidence, and nature of potential effects to human health that may occur as a result of exposure to the COCs at the site. The quantitative and qualitative results of the data evaluation, exposure, and toxicity assessment sections were combined to calculate risks for cancer and noncancer health effects. Because of fundamental differences in the mechanisms through which carcinogens and noncarcinogens act, risks were characterized separately for cancer and noncancer effects.

6.2.4.1 Carcinogenic Risks

The potential health risks associated with carcinogens were estimated by calculating the increased probability of an individual developing cancer during their lifetime as a result of exposure to a particular chemical at the site. The chemical-specific exposure estimates (i.e., average lifetime dose) were multiplied by the chemical- and route-specific slope factor, averaged over a lifetime of 70 years, to arrive at a unitless probability (e.g., 1×10^{-4}) of an individual developing cancer as a result of chemical exposures at the site.

A cancer risk estimate is a probability that is expressed as a fraction less than 1. For example, a cancer risk of 0.0001 (or 1×10^{-4}) refers to an upper-bound increased chance of one in ten thousand of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime. The National Oil and Hazardous Substances Pollution Contingency Plan recommends a target risk goal range for excess cancer risk of 0.000001 to 0.0001 (or 10^{-6} to 10^{-4}).

6.2.4.2 Noncarcinogenic Hazards

The potential for noncarcinogenic effects due to exposure to a particular chemical is expressed as the hazard quotient (HQ). An HQ was calculated by dividing the estimated intake or dose of a chemical by the chemical-specific toxicity value or noncancer Rfd. Implicit in the HQ is the assumption of a threshold level of exposure below which no adverse effects will occur. If the HQ exceeds unity (i.e., is greater than 1), site-specific exposure exceeds the Rfd and the potential for noncarcinogenic adverse effects may exist.

6.2.4.3 Results

Tables 6-4 and 6-5, as well as the sections below, summarize the risk characterization results for each exposure scenario evaluated for this site.

Total Risk and Hazard Results for Groundwater Used as Tap Water

The risks and hazards to adult residents (assuming lifetime exposures) were calculated using data from each well and from all site data (combined data from all monitoring wells) assuming a future exposure scenario. These risks and hazards were based on combined ingestion, dermal contact, and inhalation exposures during all indoor use of tap water. Carcinogenic risks for residents at each of the 19 individual monitoring wells (MWs) ranged from 2×10^{-7} to 2×10^{-4} , while the noncarcinogenic hazards ranged from 0.009 to 7 under RME conditions. CT risks and hazards ranged from 2×10^{-8} to 2×10^{-5} and 0.003 to 3, respectively.

Because adult residents are not likely to be exposed to only the risk and hazard derived from data collected at one well, a risk and hazard were also calculated for all the site data combined (without regard to sample location). Data collected from the entire site may better represent the average exposures to residents throughout the area. The carcinogenic risk and noncarcinogenic hazard from combined ingestion, dermal contact, and inhalation of groundwater for adult residents at the site were 1×10^{-4} and 5, respectively, under RME conditions. CT risk and hazard were 8×10^{-6} and 1, respectively. The RME cancer risk is at the highest target risk goal of 10^{-4} , whereas the CT risk is within the risk goal range of 10^{-4} to 10^{-6} . The RME hazard of 5 for all site data exceeded the target HQ of 1.0. In contrast, the CT hazard of 1 is equal to the target HQ. The RME noncarcinogenic hazard from combined exposures to groundwater for children as residents was estimated at 11, which exceeds the target HQ of 1.0.

Total Risk and Hazard Results for Surface Water in Ditch

The cancer risk and hazard to children (4 to 11 years old) playing in the ditch were calculated for the incidental ingestion and dermal contact pathways assuming a current exposure scenario. For

incidental ingestion the risk was 2×10^{-8} and the hazard was 0.0008. For dermal contact, the risk was 9×10^{-8} and the hazard was 0.003. Combining both exposure pathways, the total risk was 1×10^{-7} and the total hazard was 0.004.

The cancer risk value of 1×10^{-7} from combined exposures does not exceed the lowest target risk goal of 10^{-6} and it also does not exceed the MTCA risk goal of 10^{-5} for multiple pathways. The RME hazard of 0.004 is well below the target HQ of 1.0.

Total Risk and Hazard Results for Surface Water in Crawlspace

The cancer risk and hazard to both children and adults exposed (over an exposure period of 30 years, assuming that COC concentrations remain constant) to chemicals volatilizing from surface water in crawlspaces were calculated for the inhalation pathway. The total risk was 6×10^{-4} and the total hazard was 47 assuming exposure to the average surface water concentrations of PCE and TCE volatilizing from the crawlspace.

The cancer risk value of 6×10^{-4} exceeds the target risk goal range of 10^{-4} to 10^{-6} , and it also exceeds the MTCA risk goal of 10^{-5} . The hazard of 47 is well above the target HQ of 1.0. Using the maximum surface water concentrations to estimate the indoor air levels of PCE and TCE, the total risk was 3×10^{-3} and the total hazard was 275, which also exceed the target health goals.

6.2.5 Risk Assessment Uncertainties

The purpose of a risk assessment is not to predict the actual risk of exposure to an individual. Rather, risk assessments are a management tool for developing conservative estimates of health hazards in order to be protective of the majority of the population and to compensate for uncertainties inherent in estimating exposure and toxicity. As a result, the numerical estimates in a risk assessment (risk values) have associated uncertainties reflecting the limitations in available knowledge about site concentrations, exposure assumptions (e.g., chronic exposure concentrations, intake rates, frequency of time spent at home), and chemical toxicity.

6.2.5.1 Data Collection and Evaluation

Despite the amount of sampling of soil and water at the site over the years, some unsampled areas of the site could have higher concentrations than the available sampling data indicate. Sampling every square inch of a site is technically infeasible and this source of uncertainty is somewhat balanced by the use of upper-bound (95 percent upper confidence limit [UCL]) concentrations and conservative modeling and exposure assumptions. The use of the UCL and conservative assumptions tend to overestimate the true mean, so that the true mean is most likely less than the value used, resulting in a probable overestimate of risk.

Air concentrations for the inhalation of groundwater pathway (during all indoor use of tap water) were estimated from the groundwater data using conservative default values (e.g., volatilization factors) that are not likely to reflect the actual conditions at the site. Therefore, the inhalation pathway used a conservative exposure estimate, which would likely bias the calculated risks and hazards upwards. The rate of volatilization of chemicals from the crawlspaces through the foundations and into the living spaces were based on the following conservative assumptions:

- The dissolved water concentrations of PCE and TCE remain constant
- The equilibrium partitioning between dissolved chemicals in surface water and chemical vapors is linear
- Vapor-phase diffusion through the ground surface is at steady-state
- No biodegradation or other means of degradation occurs during diffusion through the foundation
- Well-mixed atmospheric dispersion of the emanating vapors within the enclosed space is negligible in comparison with diffusive transport

Because these conservative assumptions represent conditions under a worst-case scenario, they bias the indoor air concentrations of chemicals upwards and, therefore, risks and hazards are likely overestimated for the indoor inhalation pathway. For example, the model assumes no biodegradation or atmospheric dispersion of vapors, both of which however would be occurring. Default values (instead of site-specific parameters) used in the formulas presented in the risk assessment may have caused either an over- or under-estimation of risks and hazards.

6.2.5.2 Exposure

The calculated risk and hazard for the surface water exposure pathway is likely to have been overestimated. Children (4 to 11 years old) may not actually play in the ditch with the surface water for 6 months out of the year, twice a week. A fence and overgrown blackberry bushes may serve as barriers to children entering the ditch area. In addition, the incidental ingestion rate of 30 mL/hour used in the risk calculations may greatly overestimate risks because the rate is based on exposures during swimming. Children are not likely to swim in surface water at this site because of the shallow depth of the water and of the ditch. The skin surface area of 3,400 cm² used in the risk assessment may also overestimate the risks to children. This value is based on exposure of the legs and feet of a child. However, due to the cool coastal weather conditions of Washington state, children may likely wear clothing to cover their legs and feet for a portion of the 6-month exposure period.

Likewise, for exposures to both children and adults (for an exposure duration of 30 years) via inhalation of indoor air contaminants volatilizing from surface water in crawlspaces into living areas, the calculated risks and hazards are likely overestimated. Many conservative assumptions were built into the model used to derive the indoor air concentrations (as described in Section 6.2.5.1). Moreover, the exposure parameters used in calculating the risk and hazard may have been overly conservative (e.g., the exposure frequency and duration of 350 days per year for over 30 years). If, however, groundwater concentrations were used instead, the risk and hazard values may be higher, because open air, rainwater, and surface water runoff dilute surface water but not groundwater concentrations. Moreover, if the surface water concentrations detected in the two crawlspace samples were used, the risk and hazard values will undoubtedly be higher.

6.2.5.3 Toxicity Assessment and Risk Calculations

The risk and hazard calculations combine uncertainties in the data evaluation, exposure assessment, and toxicity assessment sections. Uncertainty surrounding the use of PCE and TCE slope factors is due to unresolved scientific issues regarding the carcinogenicity classification of these chemicals.

The carcinogenicity classification of PCE and TCE as Group C-B2 carcinogens (C: possible human carcinogen, B2: probable human carcinogen) has a long history. The slope factors were found in IRIS from 1987 to 1989, but have since been withdrawn. A final position for the classification of PCE and TCE has yet to be determined. The PCE and TCE slope factors will not be finalized until the EPA Working Group re-evaluates the weight-of-evidence classification. The Working Group expects to release a draft revised toxicity evaluation some time in the year 2000. However, the slope factors for PCE and TCE were reported in an NCEA paper and in EPA Region 9's PRG Tables. These slope factor values were used in the risk assessment to calculate risks from exposure to PCE and TCE. However, due to the indeterminate carcinogenicity classification for PCE, the use of these slope factors was an uncertainty in the risk assessment.

6.2.6 Conclusions

Using the most up-to-date methods of risk assessment, which conservatively evaluate the potential for risk, this risk assessment finds carcinogenic and noncarcinogenic risks for adult residents exposed to PCE and TCE (over a lifetime) via combined ingestion and dermal contact with groundwater, and inhalation of volatiles emitted from groundwater during all indoor use of tap water. These risks are only likely to occur under a future exposure scenario. However, remediation strategies (soil vapor extraction system at Southgate Dry Cleaners and air-strippers at the wellhead) are currently in place to prevent PCE and TCE from infiltrating the public water supply system.

The risk assessment did not find significant risks to children (4 to 11 years old) exposed to PCE and TCE via dermal contact and incidental ingestion of surface water while playing in the ditch. This pathway involves many uncertainties in its evaluation because children are not expected to spend a considerable amount of time in the ditch. Moreover, access to the ditch is limited by the presence of a fence and overgrown blackberry bushes. The estimated noncarcinogenic hazard and carcinogenic risk were well below the target HQ of 1.0 and between the target risk goal range of 10^{-4} and 10^{-6} , respectively.

The risk assessment did find, however, risks and hazards above EPA and Washington State Model Toxics Control Act (MTCA) guidelines to both children and adults exposed via inhalation of predicted air concentrations of PCE and TCE diffusing into living areas from crawlspaces.

6.3 ECOLOGICAL RISK ASSESSMENT

The screening level ecological risk assessment of groundwater seeping into surface water drainages at the Palermo Wellfield site identified TCE and PCE as chemicals with a potential to pose adverse ecological risks to aquatic biota. During the screening level ecological risk assessment, a conservative exposure scenario to assess ecological risks of groundwater was used. The scenario assumed that an aquatic receptor could be exposed to the maximum detected groundwater concentration of TCE and PCE within any well at the site during its entire lifetime. Under this scenario, both TCE and PCE in groundwater were identified as potential chemicals of ecological concern. This was based on the maximum detected groundwater TCE and PCE concentrations exceeding the EPA Ecotox threshold of 350 $\mu\text{g/L}$ TCE and 120 $\mu\text{g/L}$ PCE. TCE and PCE concentrations in water associated with adverse effects to aquatic biota were identified through a review of the EPA Aquatic Toxicity Information Retrieval Database (AQUIRE).

Surface water at the Palermo Wellfield site comes in part from a series of groundwater seeps, which contribute to the flow in a ditch running behind a group of homes. Habitat for fish and other aquatic species is poor, as the ditch is straight with no meanders and few structures (rocks, branches, aquatic vegetation, etc.). This leads to a possibility that few or no aquatic ecological receptors are present at the surface water locations with the highest chemical concentrations. A biological survey of the ditch has not been performed, so it is uncertain whether any aquatic receptors actually reside at the site. The combination of groundwater dilution by larger volumes of surface water, volatilization and degradation processes within surface water make it extremely unlikely that any aquatic receptor would be exposed to the maximum concentrations of chemicals found in groundwater for any appreciable length of time. This is particularly true for surface water discharged from the ditch to the Deschutes River. The drainage ditch at the Palermo Wellfields site is approximately 465 feet in length. The drainage ditch behind the homes

discharges into a stormdrain which ultimately empties into a golf course ditch, which eventually discharges into the Deschutes River (Figure 2-1).

Both anadromous and freshwater fish species are known to spawn within and utilize the available habitat within the Deschutes River. Within the State of Washington, species of concern include those species listed as State Endangered, State Threatened, State Sensitive or State Candidate, as well as federally listed or proposed for listing species by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. Fish species of concern known to be present in the Deschutes River are chinook salmon (*Oncorhynchus tshawytscha*), a federal threatened and Washington candidate species; and the Olympic mudminnow (*Novumbra hubbsi*), a Washington candidate species which has been recommended for sensitive status. Chinook salmon stocks in the Deschutes River have not been extensively studied. They are believed to be primarily of hatchery origin, however, the presence of native fish cannot be ruled out.

The exposure pathways for aquatic receptors to contaminated surface water are unlikely to be complete. No detectable TCE or PCE concentrations were found in surface water of ditches and in crawlspaces (Table 6-2) in excess of ecological risk-based screening concentrations. Aquatic receptors are unlikely to be present in the ditch at the points of groundwater discharge. Concentrations of TCE and PCE in surface water discharged to the Deschutes River will be diluted to levels even lower than those detected in ditches, and below those associated with toxicity to aquatic biota. Furthermore, analysis of the AQUIRE aquatic toxicology database showed that the maximum concentrations of TCE and PCE measured in surface water are below a level of ecological concern.

Table 6-1
Groundwater COCs and their Exposure Point Concentrations

Well ID	Tetrachloroethene (PCE)		Trichloroethene (TCE)	
	RME Concentration (µg/L)	CT Concentration (µg/L)	RME Concentration (µg/L)	CT Concentration (µg/L)
All Site Data	23.57	17.62	162.78	85.05
100 (MW-100)	0.2 U	0.2 U	0.2 U	0.2 U
101 (MW-101A)	0.2 U	0.2 U	19.56	11.17
102 (MW-102)	0.2 U	0.2 U	0.2 U	0.2 U
103 (MW-103)	0.2 U	0.2 U	0.31	0.276
104 (MW-104A)	0.2 U	0.2 U	55.47	12.99
105 (MW-105)	0.2 U	0.2 U	8.26	6.187
107 (MW-107)	0.2 U	0.2 U	0.2 U	0.2 U
109 (MW-109)	0.2 U	0.2 U	31.54	21.69
110 (MW-110)	0.2 U	0.2 U	0.2 U	0.2 U
111 (MW-111)	0.2 U	0.2 U	34.3	28.06
121 (MW-101B)	0.2 U	0.2 U	14.8	12.93
124 (MW-104B)	2.48	1.98	0.2 U	0.2 U
401 (MW-ES-01)	0.852	0.579	41.25	16.1
402 (MW-ES-02)	2.5	1.34	135.71	126.3
403 (MW-ES-03)	99.85	48.76	73.12	61.38
404 (MW-ES-04)	201.5	173.4	164.03	21.74
405 (MW-ES-05)	1.75	1.01	72.76	57.6
406 (MW-ES-06)	209.3	148.8	140	33.77
407 (MW-ES-07)	1.44	0.974	18.73	13.88
408 (MW-ES-08)	2.8	1.02	0.676	0.521
409 (MW-ES-09)	1.11	0.806	255.6	205.6
410 (MW-ES-10)	0.644	0.556	76.15	59.03
411 (MW-ES-11)	0.619	0.498	1.92	1.17
674 (MW-02)	0.5 U	0.5 U	0.5 U	0.5 U
675 (MW-4A)	0.5 U	0.5 U	0.5 U	0.5 U
676 (MW-4B)	0.5 U	0.5 U	0.5 U	0.5 U
687 (MW-93-03)	1 U	1 U	1 U	1 U

Notes:

CT - central tendency (average)

µg/L - micrograms per liter

MW - monitoring well

RME - reasonable maximum exposure

U - not detected at the laboratory method detection limit listed

Table 6-2
Surface Water COCs and their Exposure Point Concentrations

Chemical of Concern	Units	Maximum Concentration	RME Concentration	CT Concentration
Tetrachloroethene	(µg/L)	102	20.25	13.33
Trichloroethene	(µg/L)	115	19.55	12.92

Table 6-3
Summary of Exposure Factors

Exposure Factors	Groundwater		Surface Water in Ditch	Surface Water in Crawlspace
	RME	CT	RME	
Receptor (Age in years)	adults (lifetime exposure)	adults (lifetime exposure)	children (4 - 11)	children and adults (0-30)
Body weight (kg)	70	70	28	15c, 70a
Ingestion rate of water	2 L/day	1.4 L/day	30 ml	NE
Skin surface area (cm ²)	23,000	20,000	3,400	NE
Inhalation rate (m ³ /day)	20	13	NE	10c, 20a
Permeability constant (cm/hour)	PCE: 0.048 TCE: 0.016	PCE: 0.048 TCE: 0.016	PCE: 0.048 TCE: 0.016	NE
Exposure time (hours/day) - showering/bathing (dermal pathway)	0.25	0.167	NE	NE
Exposure frequency (days/year) - showering/bathing	350	350	NE	NE
Exposure time and frequency - playing in ditch	NE	NE	1 hr/day for 52 days/year	NE
Exposure frequency (days/year) - ingestion and inhalation of groundwater	350	234	NE	NE
Exposure frequency (days/yr) - inhalation of surface water in crawlspace	NE	NE	NE	350
Exposure duration (years)	30	9	7	6c, 24a

Notes:

a - adult

c - child

CT - central tendency (average)

µg - micrograms per liter

NE - not evaluated

RME - reasonable maximum exposure

Table 6-4
Summary of Risk and Hazard Results for Groundwater Used as Tap Water

Location ID	Location Well	Reasonable Maximum Exposure		Central Tendency Exposure	
		Risk	Hazard	Risk	Hazard
101	MW-101A	1×10^{-5}	0.5	7×10^{-7}	0.1
103	MW-103	2×10^{-7}	0.009	2×10^{-8}	0.003
104	MW-104A	3×10^{-5}	2	8×10^{-7}	0.2
105	MW-105	4×10^{-6}	0.2	4×10^{-7}	0.08
109	MW-109	2×10^{-5}	0.9	1×10^{-6}	0.3
111	MW-111	2×10^{-5}	0.9	2×10^{-6}	0.3
121	MW-101B	7×10^{-6}	0.4	8×10^{-7}	0.2
124	MW-104B	2×10^{-6}	0.01	2×10^{-7}	0.004
401	MW-ES-01	2×10^{-5}	1	1×10^{-6}	0.2
402	MW-ES-02	7×10^{-5}	4	8×10^{-6}	2
403	MW-ES-03	1×10^{-4}	2	1×10^{-5}	0.8
404	MW-ES-04	2×10^{-4}	5	2×10^{-5}	0.6
405	MW-ES-05	4×10^{-5}	2	4×10^{-6}	0.7
406	MW-ES-06	2×10^{-4}	5	2×10^{-5}	0.7
407	MW-ES-07	1×10^{-5}	0.5	1×10^{-6}	0.2
408	MW-ES-08	3×10^{-6}	0.03	2×10^{-7}	0.008
409	MW-ES-09	1×10^{-4}	7	1×10^{-5}	3
410	MW-ES-10	4×10^{-5}	2	4×10^{-6}	0.7
411	MW-ES-11	1×10^{-6}	0.06	1×10^{-7}	0.02
All Site MW Data		1×10^{-4}	5	8×10^{-6}	1

Note:
MW - monitoring well

Table 6-5
Summary of Human Health Risks and Hazards

Exposure Pathway	RME Scenario		CT Exposure Scenario	
	Cancer Risk	Hazard	Cancer Risk	Hazard
Groundwater as tap water ^a				
At one well ^b	2×10^{-4}	5	2×10^{-5}	3
All site data ^c	1×10^{-4}	5	8×10^{-6}	1
Surface water in ditch ^d	1×10^{-7}	0.004	NE	NE
UCL ₉₅ of all SW data				
Surface water in crawlspaces ^e	6×10^{-4}	47	NE	NE
UCL ₉₅ of all SW data				

^a The groundwater pathway includes exposures to adult residents by ingestion, dermal contact, and inhalation during all household use of tap water (lifetime exposures were evaluated).

^b The maximum risk and hazard were based on data collected from one well.

^c The maximum risk and hazard were based on data collected from the entire site (includes all MW data).

^d Pathway includes exposures to children by incidental ingestion and dermal contact while playing in the ditch.

^e This pathway includes exposures to children and adults (over a 30-year exposure period) via inhalation of indoor air contaminants volatilizing from surface water in crawlspaces into living areas.

Notes:

The target acceptable risk range is 10^{-4} to 10^{-6} .

Acceptable Hazard Quotients are less than 1.0.

CT - central tendency (average)

MW - monitoring well

NE - not evaluated

RME - reasonable maximum exposure

SW - surface water

UCL₉₅ - 95 percent upper confidence limit

7.0 REMEDIAL ACTION OBJECTIVES

7.1 NEED FOR REMEDIAL ACTION

The clearest and most direct need to take cleanup action was demonstrated by the finding of TCE in a municipal wellfield at levels greater than drinking water standards (maximum contaminant levels [MCLs]). The upgradient drinking water aquifer was also found to be contaminated with both TCE and PCE at levels greater than the MCLs. The results of the baseline human health and ecological risk assessments indicate that potential long-term unacceptable risks associated with groundwater, surface water, soil, and indoor air at the site are above acceptable concentrations defined under both the state (MTCA) and federal (Superfund) regulations. Actual or threatened releases of hazardous substances from this site, if not addressed by remedial actions, may represent a current or potential threat to public health, welfare, or the environment. Consistent with the NCP and EPA policy, remedial action is warranted to address these potential risks.

Remedial action objectives (RAOs) consist of medium-specific or location-specific goals for protecting human health and the environment. The objectives should be as specific as possible, but not so specific that the range of alternatives that can be developed is unduly limited. RAOs were developed for the Palermo Wellfield Superfund Site for those chemicals of concern identified by comparing laboratory results to chemical-specific regulations and as a result of the baseline risk assessment. The ARARs addressed in the FS report include federal drinking water standards and MTCA cleanup levels that focus on water quality standards, on human exposure via direct contact or via ingestion of soil, groundwater, or surface water, and on human exposure via inhalation of vapors.

7.2 RAOs

The following RAOs have been developed for the Palermo Wellfield Superfund Site:

- Clean up aquifer
- Prevent ingestion of, or exposure to, groundwater containing carcinogens in excess of ARARs and total excess cancer risk greater than 10^{-4} to 10^{-6} .
- Prevent inhalation of COC vapors from surface water in residential crawlspaces at concentrations that result in a total excess cancer risk of greater than 10^{-6} .

- Prevent discharge of groundwater containing COCs to the Deschutes River at concentrations in excess of ARARs or resulting in ecological HI greater than 1.
- Reduce the potential for PCE in soils under the Southgate Dry Cleaners to reach the groundwater.

The rationale for each of the RAOs and the establishment of cleanup goals is described in the following subsections. The RAOs and cleanup goals are summarized in Table 7-1.

7.2.1 TCE and PCE in Groundwater

The first RAO for protection of human health is to prevent the ingestion of, or domestic use of, groundwater containing TCE or PCE at concentrations in excess of drinking water levels. The current point of exposure to groundwater is the Palermo Wellfield. Because the Palermo Wellfield Superfund Site is within a developed area served by municipal water systems, private wells that could constitute additional points of exposure to groundwater do not currently exist. However, the plume of contaminated groundwater poses a health hazard if anyone drills a well into the plume and uses the water for a domestic water supply without treatment. Land use above the contaminated plume of groundwater is currently commercial (in the upland area) and residential (in the Palermo Valley). Land use is expected to remain the same into the foreseeable future. The remediation goals (RGs) established for TCE and PCE are both 5 ppb, which is the MCL established under the federal Safe Drinking Water Act and the State of Washington MTCA Method B cleanup levels for these compounds. The point of compliance is throughout the aquifer on the site.

7.2.2 TCE and PCE in Vapors Emanating from Surface Water

The second RAO for protection of human health is prevention of inhalation of vapors containing TCE or PCE potentially emitted by groundwater seepage (surface water) that ponds within the crawlspaces of the residences along the west side of Rainier Avenue. Sampling has shown that the standing water under some of these residences contains TCE and PCE. Modeling has demonstrated that an excess cancer risk from inhalation exists because vapors from this standing water have the potential to migrate into the living spaces of the homes at levels that can cause adverse health affects. The cleanup goal for indoor air is based on the MTCA Method B ambient air cleanup level. These levels are $1.46 \mu\text{g}/\text{m}^3$ and $4.38 \mu\text{g}/\text{m}^3$ for TCE and PCE, respectively. No RAO has been developed for prevention of direct contact with the groundwater seepage because no hazard or excess cancer risk was identified for this pathway in the baseline risk assessment.

Modeling indicates that lowering the groundwater table to a depth of at least 18 inches below the bottom of the crawlspaces will reduce potential risks to acceptable levels. Lowering of the groundwater table will result in a lower contribution of PCE and TCE to indoor air from the surface water (or shallow groundwater). There may be other sources of PCE and TCE in the residences (such as building materials, cleaning agents, and clothes that have been dry cleaned) that are unrelated to the PCE and TCE in surface water (shallow groundwater). Because of these other sources of PCE and TCE in indoor air, and the technical difficulties in obtaining representative air samples, the measure of effectiveness of the remedy for surface water will be to demonstrate lowering of the groundwater table to a depth of 18 inches below the bottom of the crawlspaces (as opposed to direct indoor air sampling).

The numerical RGs for PCE and TCE in surface water (shallow groundwater) have been established by calculating the concentrations of PCE and TCE that correspond to an acceptable indoor air inhalation risk level in the absence of any remedy (i.e., the crawlspaces contain standing water). These RGs are 0.05 ppb and 0.027 ppb for PCE and TCE, respectively. These concentrations are below standard analytical method detection limits. In practice, the actual remediation goal will be the method detection limit for the analytical method used. Because of the conservative nature of the modeling conducted to estimate indoor air concentrations of TCE and PCE, and because the resulting RGs for crawlspace water are two orders of magnitude below drinking water standards, EPA will review the appropriateness of these RGs and the methodology to assess compliance with the indoor air cleanup levels during the Five-Year Review. Current land use in the Palermo neighborhood is residential and is expected to remain the same into the foreseeable future.

7.2.3 Soil to Groundwater Transfer of PCE

The third RAO for protection of human health is reduction of the potential for PCE sorbed onto soil particles beneath the Southgate Dry Cleaners to partition into the groundwater. The objective of this RAO is to reduce the potential of contaminated soil to act as a source for future groundwater contamination. The RG of 0.0858 mg/kg is based on the MTCA Method B soil cleanup levels for the protection of groundwater. Attainment of the soil RG goal will be evaluated based on PCE concentrations in vapor discharged from the remediation system. The change in the PCE concentrations in vapor from the initial concentration to the most recent concentration will be used to establish the present PCE concentration in soil based on the initial PCE concentration in soil.

Attainment of the soil RG will be confirmed by soil sampling. If these confirmation soil samples indicate that the soil RGs have not been attained, deed restrictions will be put in place on the Southgate Dry Cleaners property to reduce the future transfer of contaminants from soil to groundwater. Because the levels of TCE remaining in soils are below MTCA standards set for

the protection of groundwater, no RAO or cleanup goals are being established for TCE in soils. No RAO or cleanup goal has been developed for prevention of direct contact with soil because no hazard or excess cancer risk was identified for this pathway in the baseline risk assessment.

7.3 DISTRIBUTION AND VOLUME OF CONTAMINANTS EXCEEDING REMEDIATION GOALS

7.3.1 Soil

Soil sampling during the RI identified five discrete locations within the study underlain by soil above the static water level containing PCE or TCE. Of these five, only two currently exhibit a significant lateral extent of PCE concentrations in soil greater than the RG: Southgate and Brewery City Pizza (Figure 7-1). No significant lateral extent of TCE in soil at concentrations greater than the RGs was identified within the study area. As discussed in Section 5.5.3, the PCE identified in soil beneath Brewery City Pizza is likely the result of partitioning from groundwater to soil vapor, followed by adsorption from vapor onto soil in the unsaturated zone. Figure 7-1 shows the estimated distribution of soil containing PCE concentrations above the RG. This figure was used to estimate the volume of impacted soil.

Prior to installation of the soil vapor extraction remediation system, PCE was detected in soil samples at Southgate from the ground surface to the groundwater surface at 30 to 40 feet bgs. The estimated soil volume containing a PCE concentration greater than the RG of $85.8 \mu\text{g/kg}$ was approximately 6,400 cubic yards. This soil appeared to be primarily located at a depth range of 0 to 15 feet bgs under Southgate Dry Cleaners. The soil vapor extraction remediation system has been operating since March 1998. As of March 30, 1999, an estimated 410 pounds of PCE had been removed by the remediation effort.

PCE in soil at Brewery City Pizza is observed in soil samples from as shallow as 10 feet bgs to the groundwater surface at approximately 50 feet bgs. PCE in soil (at a concentration below the RG) was detected at 10 feet bgs in samples collected by R.F. Weston during their Phase I sampling in 1995. The estimated soil volume containing a PCE concentration greater than the RG near Brewery City Pizza is approximately 5,300 cubic yards. This soil is located near the groundwater surface at approximately 45 to 65 ft bgs.

7.3.2 Groundwater

Two distinct plumes of VOCs in groundwater have been identified: one of PCE and one of TCE. Figures 7-2 and 7-3 show the distribution of PCE and TCE in groundwater above RGs,

respectively. These figures were used to calculate the volume of PCE and TCE in groundwater at concentrations exceeding the RGs.

PCE in Groundwater

West of the Palermo Bluff, in the uplands area, depth to groundwater in the area of PCE contamination ranges from 10 to 50 feet bgs. Overall, PCE concentrations greater than the RG in this area were detected from the groundwater surface to 110 feet bgs. The lateral and vertical distribution of PCE in groundwater within the lateral limits shown on Figures 7-2 is variable, and not continuous within these limits.

East of the Palermo Bluff, in the Palermo Valley, depth to groundwater is 0 to 10 feet. PCE concentrations greater than the RG are found in surface water (seeping groundwater) and to depths of less than 10 feet. The estimated total volume of groundwater beneath the study area containing PCE above the RG of 5 $\mu\text{g/L}$ is approximately 1.8 to 4.3 million cubic feet (Mft³) or 13 to 32 million gallons (Mgal).

Presence or Absence of NAPLs

The primary contaminants found at the site (TCE and PCE) can dissolve in groundwater or, under certain conditions, can remain as undissolved, or free-phase, liquids (non-aqueous phase liquids, or NAPLs). The most frequently detected analytes at the site, PCE and TCE, are both denser than water and could therefore form a dense NAPL (DNAPL). DNAPL, if present, would sink through the saturated zone and provide a constant source of dissolved contaminant. Bulk or free-phase chemicals can also remain adhered to soil in the vadose zone, or capillary fringe, just above the groundwater zone and act as a continuous contaminant source to groundwater over time.

Identification of DNAPL pooled in the aquifer is important because a small amount of DNAPL can have a substantial effect on contaminant concentrations. However, identification of DNAPL through sampling can be difficult. The potential for the presence of DNAPL pooled in the aquifer at the site was evaluated by considering site and contaminant characteristics that are typical indicators of the presence or absence of DNAPL. These indicators include the following:

- Historical use of solvents at the site
- Releases of solvents at the site
- Concentrations of solvents in soil that exceed the maximum capacity of the soil organic matter to adsorb solvents plus the maximum potential dissolved concentration in soil mixture

- Aqueous concentrations of solvents exceeding 1 percent of their solubility limit
- Organic vapor concentrations in soil gas exceeding 100 ppm
- Continued generation of an aqueous plume in the absence of any other contributing source

Historical use of solvents that have the potential to form DNAPL in the groundwater within the site boundaries has been documented at the WDOT MTL and Southgate Dry Cleaners. At the WDOT MTL, a 1970 solvent release from an underground storage tank was documented in a 1996 facility audit. At Southgate Dry Cleaners, the evidence for a release of solvents includes the presence of an abandoned dry well or sump, the presence of high concentrations of solvents in soil from ground surface to the groundwater surface, and the detection of high concentrations of solvents in groundwater beneath the site. The release mechanisms at these sources are not fully known. The available evidence suggests that the release from WDOT MTL consisted of dissolved contaminants in wastewater, and that some of the release from Southgate Dry Cleaners may have been in the form of NAPL.

PCE has been measured at concentrations in soil at Southgate Dry Cleaners above the maximum theoretical concentration that could be adsorbed by soil organic matter plus dissolved in residual soil moisture. Such concentrations have not been observed at other locations such as Chevron and WDOT MTL. This may suggest a localized pocket of DNAPL at Southgate Dry Cleaners. However, measured concentrations decrease quickly with depth to concentrations far below the calculated theoretical maximum at depths of 15 feet below ground surface (bgs) or less. Groundwater occurs at depths of 30 feet bgs or greater in the Southgate area, therefore, the presence of PCE in soil at concentrations greater than the calculated theoretical maximum does not necessarily confirm the presence of DNAPL pooled in the aquifer.

Measured dissolved PCE and TCE concentrations in groundwater do not exceed 1 percent of their respective solubilities in any of the groundwater samples collected from the site. Organic vapor concentrations have not exceeded 100 ppm in soil gas samples collected from the site.

Results of groundwater monitoring at the site do not suggest that the plume is continuing to expand.

In summary, direct sampling has not confirmed the presence of DNAPL at the site. However, evaluation of typical indicators of the presence of DNAPL indicates that the presence of DNAPL cannot be ruled out. Some indicators imply the absence of DNAPL, while other indicators suggest that the presence of DNAPL cannot be ruled out. If DNAPL is present at the site, it is most likely to be located beneath Southgate Dry Cleaners.

TCE in Groundwater

In the uplands area near Chevron, the depth to water is approximately 18 feet bgs. In this area TCE has been detected from the groundwater surface to depths of 35 to 40 feet bgs. To the east of Chevron, at the Interstate 5 (I-5) interchange, TCE is generally detected deeper in the aquifer, at depths ranging from 30 to 50 feet bgs to 80 feet bgs.

Immediately north of the I-5 interchange, east of the WDOT MTL, depth to groundwater is 15 to 20 feet bgs. In this area, TCE is observed from the groundwater surface to 30 feet bgs. Beneath the northwest corner of the WDOT facility, TCE is also found at the groundwater surface at a depth of 6 to 8 feet bgs, and down to 37 feet bgs in the aquifer.

Eastward across I-5 to Southgate, the depth to groundwater increases to 30 to 40 feet bgs. TCE in this area (specifically north of Southgate Dry Cleaners) is observed from the groundwater surface to 100 feet bgs. The depth of TCE detection is shallower to the south immediately beneath Southgate Dry Cleaners, from the groundwater surface to only 50 feet bgs. TCE was not detected in samples collected south of Southgate Dry Cleaners. However, groundwater sampling in this area did not exceed 75 feet. It is possible that the TCE plume extends somewhat farther south in this area than shown on Figure 7-3, but that (if present) it occurs below the depths sampled.

Eastward from Southgate across Capitol Boulevard to Brewery City Pizza, the depth to groundwater is approximately 50 feet bgs. TCE in this area is detected from the groundwater surface to 130 feet bgs. Groundwater samples area not available to preclude the possibility that TCE is present in groundwater at depths greater than 130 feet bgs.

Eastward of the Palermo Bluff, TCE is present in seeping groundwater that daylights at the base of the bluff. TCE is also detected in groundwater samples collected at depths of 86, 92, and 125 feet bgs, with no samples collected below 125 feet bgs.

The estimated total volume of groundwater containing TCE (within the entire plume area shown on Figure 7-3) above the RG of 5 $\mu\text{g/L}$ is approximately 6 to 24 Mft³ or 46 to 180 Mgal.

PCE and TCE Commingling in Groundwater

The PCE plume generally overlies the TCE plume, and the two plumes appear to commingle vertically. PCE may also be degrading to TCE. Active groundwater remediation alternatives are likely to recover groundwater containing PCE and TCE simultaneously. A combined value for the volume of groundwater containing either PCE or TCE or both in concentrations greater than RGs is therefore useful. Because of the apparent zone of commingling, this volume is not simply

the sum of the two volumes given above. Interpretation was made of the groundwater samples collected in the area where the TCE plume is overlain by the less laterally extensive PCE plume. Of these samples, approximately 50 percent contain both PCE and TCE. If 50 percent of the PCE plume is therefore assumed to be commingled with the TCE plume, the total volume of groundwater containing either PCE or TCE or both above RGs can be estimated at approximately 7 to 26 Mft³ or 53 to 196 Mgal.

The groundwater regime beneath the study area is a dynamic system. The estimated volume of contaminated groundwater migrates under the influence of gravity and pumping wells, as uncontaminated groundwater enters the study area from upgradient areas and via precipitation recharge. Removal of a single volume of groundwater would not eliminate groundwater contamination in the study area. Residual soil contamination provides an ongoing source of contaminant to uncontaminated groundwater entering the study area. Active elimination of groundwater contamination would require either direct removal of the contaminants from the soil, "flushing" of the soil in the aquifer with volumes of groundwater sufficient to mobilize and remove the soil contamination, or in-situ degradation of COCs. Flushing could conceivably require removing many times the volume of contaminated groundwater estimated above.

Surface Water

Figure 7-4 shows the results of surface water samples and groundwater samples collected from a shallow, hand-driven drive-point sampling device (GeoProbe™). The lateral extent of surface water and shallow groundwater containing TCE and PCE at concentrations greater than the RGs essentially consists of the front and back yard areas of the residences along the western side of Rainier Avenue. Because surface water is drained from this area and conveyed by the stormdrain system, water containing COCs greater than RGs is present at the stormdrain outfalls at the drainage ditch within the golf course to the east. The area where surface water is typically observed is approximately 200 feet by 600 feet, or 120,000 square feet (2.75 acres).

It appears that water containing PCE and TCE is seeping from the base of the bluff and is further distributed by the surface water drainage system towards the Deschutes River. PCE and TCE concentrations decrease as the surface water is conveyed into the City of Tumwater storm sewer system and transmitted east beneath M Street to a slough along the eastern edge of the Palermo Valley neighborhood.

Surface water samples collected from the Palermo Valley neighborhood contained PCE concentrations ranging from 0.26 to 102 µg/L, with an average concentration of approximately 28 µg/L. The highest PCE concentration was detected in the surface water sample collected from the sump that pumps water from a residential crawlspace located on the west side of Rainier Avenue (5005 Rainier Avenue).

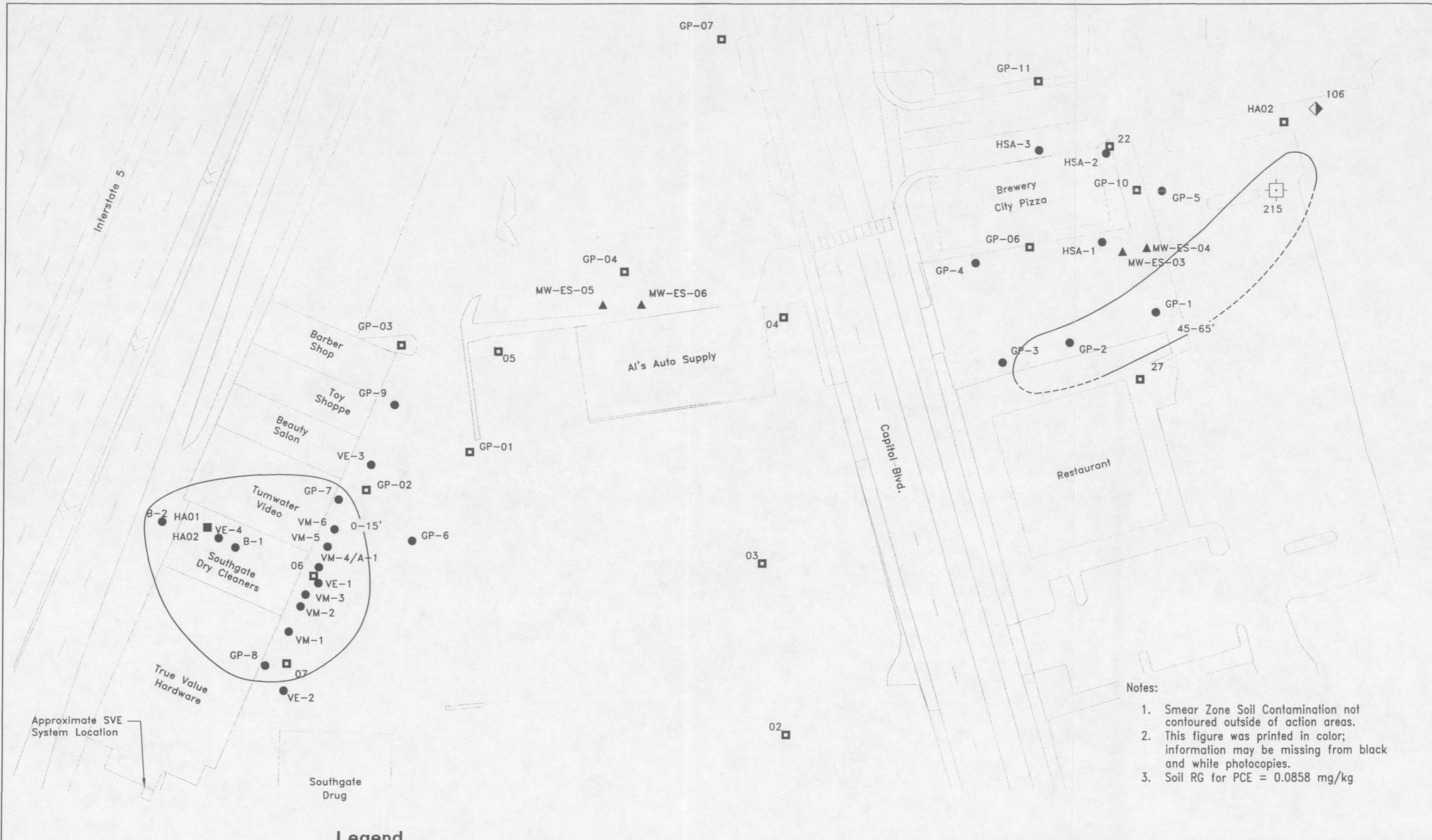
TCE was also detected in surface water samples collected from a drainage ditch east of the Palermo Wellfield. This ditch drains to the north. Samples SW-111 and SW-113 contained 4.1 and 0.50 $\mu\text{g/L}$, respectively (Figure 4-6). Sample SW-111 was collected immediately adjacent to the discharge from well TW-2, which has consistently yielded samples containing low concentrations of TCE. As a result of the TCE detections, well TW-2 was not operated for supply water production until the air stripping system began operation in February 1999 but was periodically pumped to waste into this ditch. A sample collected upgradient of sample location SW-111 at location SW-109 contained a low TCE concentration of 0.37 $\mu\text{g/L}$. Based on this observation, it appears that the low TCE detections in the ditch running east of the Palermo Wellfield are a result of well TW-2 periodically discharging into the ditch.

7.4 CHLORINATED VOC MASS ESTIMATES

Soil and groundwater volumes for specific areas of the site discussed in Section 5.6 were utilized with the concentrations of chlorinated VOCs in soil and groundwater samples to estimate the mass of chlorinated VOC in each medium in the study area. The mass estimates do not represent the total mass of PCE and TCE at the site, since they only account for the quantities above RGs. The estimates also do not include PCE or TCE that has biodegraded, volatilized, or has been removed by capture in the surface water ditch or in the wellfield. Estimated chlorinated VOC mass for each medium at each area is shown in Table 7-2. This estimate is most applicable to the time period immediately prior to the startup of the soil vapor extraction system at Southgate (March 1998).

There appears to be no significant lateral extent of soil containing PCE or TCE greater than RGs remaining in the area of the two WDOT facilities within the study area (the MTL and the maintenance facility). Because of this, no mass of chlorinated VOC can be calculated for these areas. A small area of groundwater containing TCE at concentrations greater than the RG does remain at the WDOT MTL, and a mass estimate of TCE in this area is presented in Table 5-1.

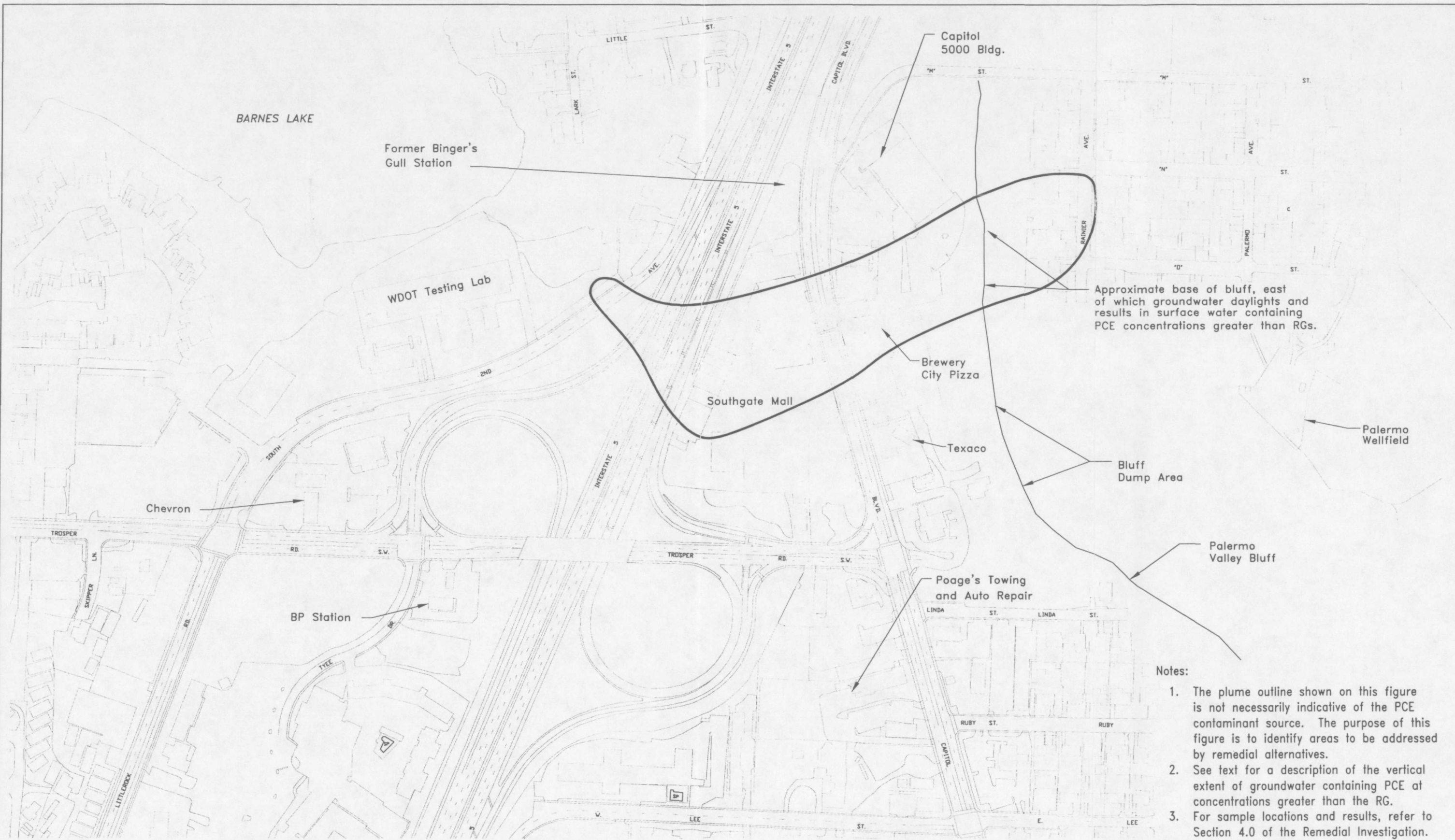
Calculation of a chlorinated VOC mass in surface water is probably not meaningful, because surface water containing chlorinated VOCs results from seepage of shallow groundwater mixing with precipitation. The volume of surface water and the chlorinated VOC concentrations in this water are therefore likely to vary substantially on a seasonal basis.



- Notes:
1. Smear Zone Soil Contamination not contoured outside of action areas.
 2. This figure was printed in color; information may be missing from black and white photocopies.
 3. Soil RG for PCE = 0.0858 mg/kg

- Legend**
- ~ Inferred lateral extent
 - 215 □ Geoprobe Sample Location
 - GP-12 ● E & E Sample Location (1997)
 - 0-8' Depths in feet below ground surface
 - 112 ◆ Soil Boring
 - GP-15 ▲ Weston Lab Sample Location (1995)
 - GP-11 □ Weston Field Sample Location (1995)
 - Listed result is an estimate.

Palermo Wellfield Superfund Site Tumwater, WA ARCS EPA REGION 10	<p>0 25 50 SCALE IN FEET</p>	<p align="center">Figure 7-1 Distribution of PCE in Soil Exceeding the Soil RG</p>
<p align="center">URS Greiner</p>		



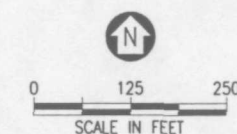
Notes:

1. The plume outline shown on this figure is not necessarily indicative of the PCE contaminant source. The purpose of this figure is to identify areas to be addressed by remedial alternatives.
2. See text for a description of the vertical extent of groundwater containing PCE at concentrations greater than the RG.
3. For sample locations and results, refer to Section 4.0 of the Remedial Investigation.

Legend

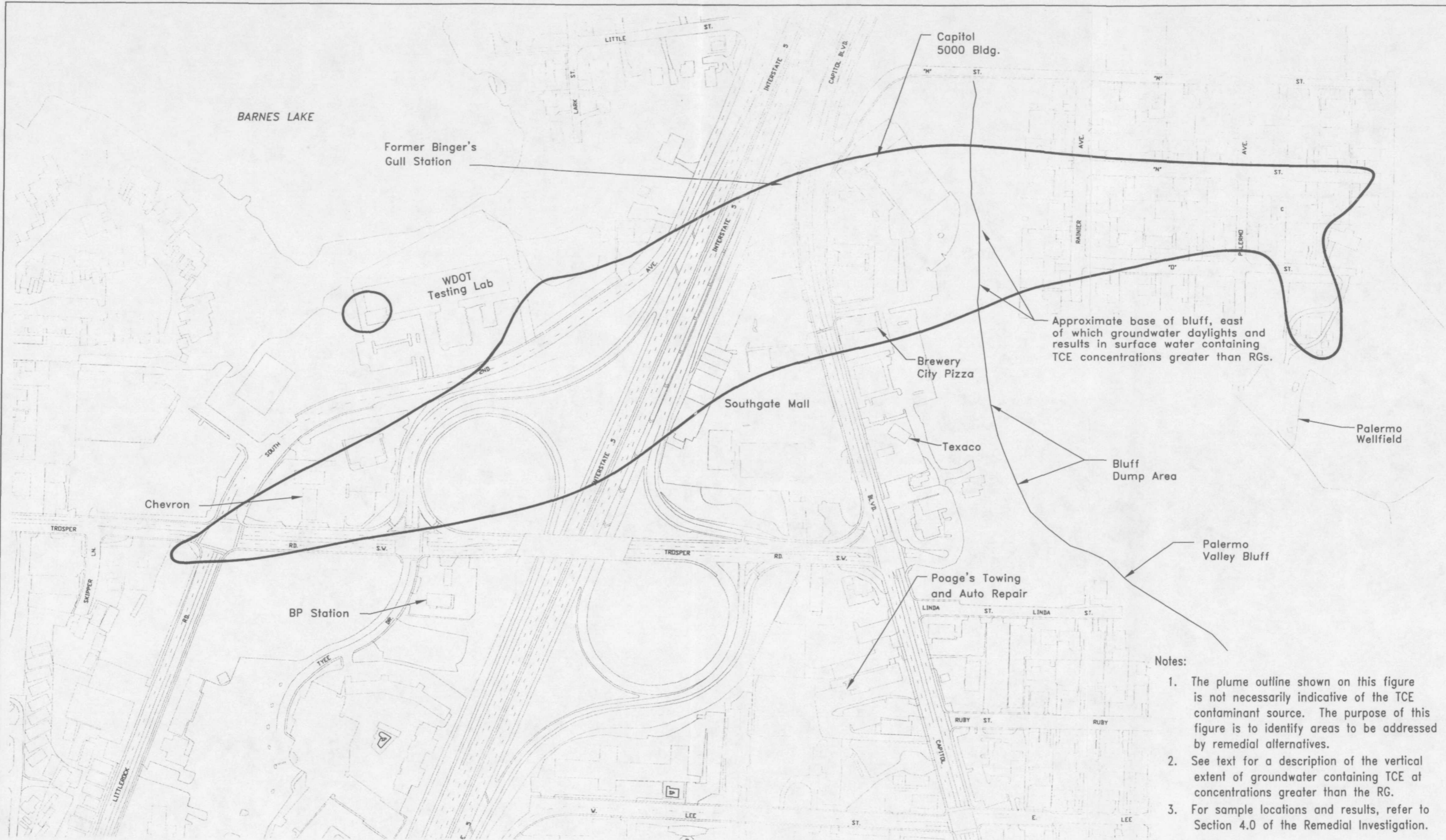
~ Approximate lateral extent of PCE in groundwater at concentrations greater than the RG = 5 ug/L

Palermo Wellfield Superfund Site
 Tumwater, WA
 ARCS EPA
 REGION 10



URS Greiner

Figure 7-2
Distribution of PCE
Exceeding the Groundwater RG



Palermo Wellfield Superfund Site Tumwater, WA ARCS EPA REGION 10	<p>0 125 250 SCALE IN FEET</p>	<p align="center">Figure 7-3 Distribution of TCE Exceeding the Groundwater RG</p>
<p align="center">URS Greiner</p>		

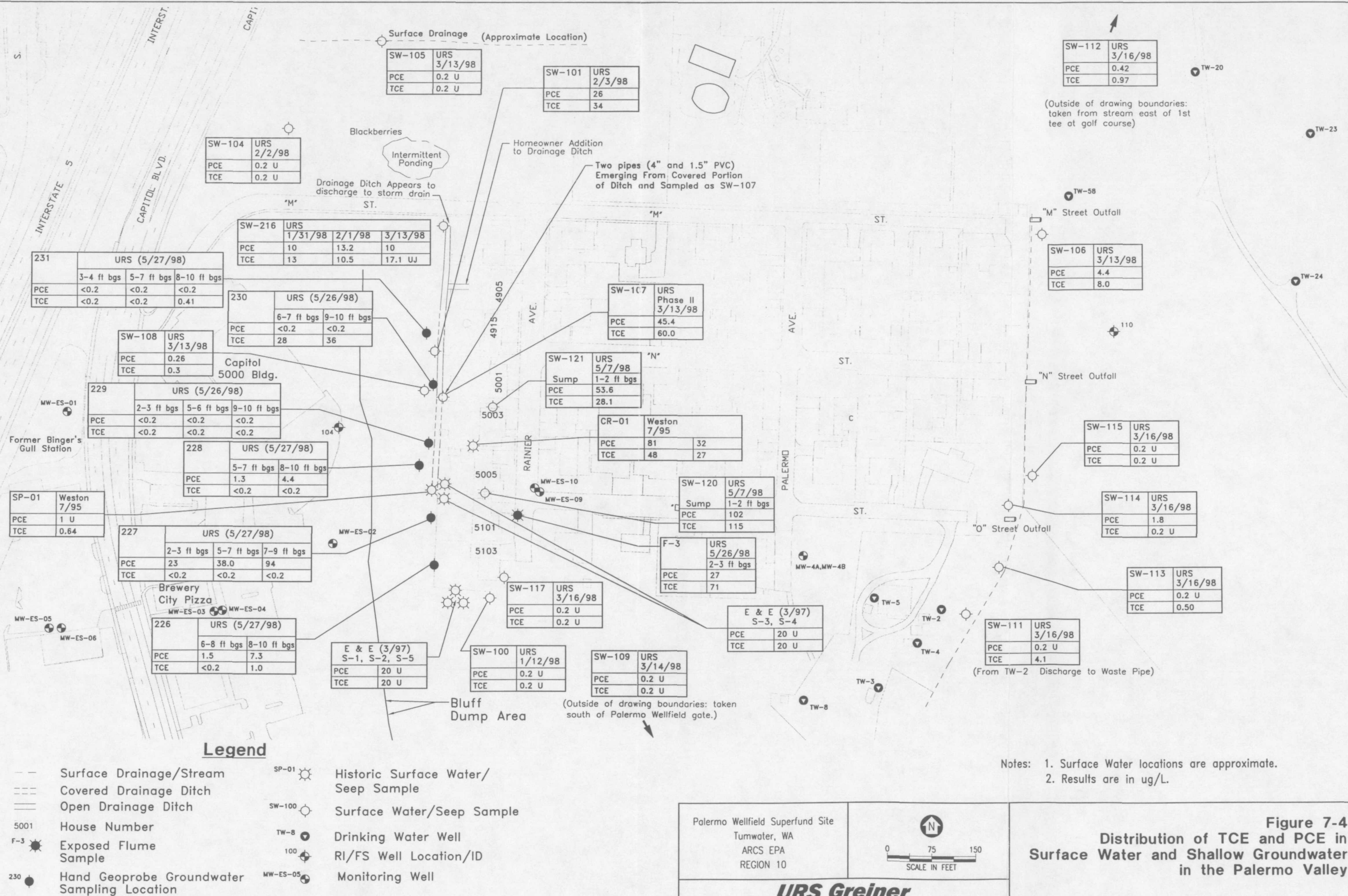


Table 7-1
Summary of RAOs and RGs

Matrix	RAOs	COC	RGs	Source of RG	Point of Compliance
Groundwater	Clean up aquifer.	PCE	5 µg/L	Federal Safe Drinking Water Act MCLs	Groundwater throughout the aquifer
		TCE	5 µg/L		
	Prevent ingestion of, or exposure to, groundwater containing carcinogens in excess of ARARs and total excess cancer risk greater than 10^{-4} to 10^{-6} .	PCE	5 µg/L		Palermo Wellfield wellheads
		TCE	5 µg/L		
Surface Water/ Indoor Air	Prevent inhalation of COC vapors from surface water in residential crawlspaces at concentrations that result in a total excess cancer risk greater than 1×10^{-6} .	PCE	0.05 ^b µg/L	Calculation from acceptable risk levels	Surface water ponded beneath residences (or shallow groundwater)
		TCE	0.27 ^b µg/L		
	Prevent discharge of groundwater containing COCs to the Deschutes River at concentrations in excess of ARARs or resulting in ecological HI greater than 1.	PCE	0.8 µg/L	National Toxics Rule ^a for consumption of water and organisms	Point of discharge to Deschutes River.
		TCE	2.7 µg/L		
Soil	Prevent soil from contaminating groundwater above health-based levels.	PCE	0.0858 mg/kg	MTCA Method B	Entire soil column to prevent groundwater contamination.
		TCE	0.398 mg/kg		

^aNational Toxics Rule - Federal Clean Water Act – National Toxics Rule 40 CFR 131.36(b)(1) Human Health (10^{-6} cancer risk)

^bThe remediation goals listed are below standard analytical detection limits. The actual remediation goal will be the method detection limit for the analytical method used. These RGs were established to help assure that MTCA Method B air cleanup levels for TCE and PCE are met in the residences along Rainier Avenue (1.46 µg/m³ for TCE and 4.38 µg/m³ for PCE). Until the RGs for surface water in residential crawlspaces is met, the measure of effectiveness of the remedy for surface water will be maintenance of the depth to shallow groundwater beneath the residences at a minimum of 18 inches.

Notes:

ARAR - applicable or relevant and appropriate requirements

Table 7-1 (Continued)
Summary of RAOs and RGs

COC - chemical of concern
HI - hazard index
MCL - maximum contaminant level
 $\mu\text{g/L}$ - micrograms per liter or parts per billion (ppb)
 $\mu\text{g/m}^3$ - micrograms per cubic meter
 mg/kg - milligrams per kilogram or parts per million (ppm)
MTCA - Model Toxics Control Act
PCE - tetrachloroethene
POC - point of compliance
RAO - remedial action objective
RG - remediation goal
TCE - trichloroethene

Table 7-2
Estimate of Chlorinated VOC Mass at Concentrations Greater Than RGs in
Portions of the Study Area as of March 1998

Reference Location	Chlorinated VOC ^a	Estimated Mass (lbs)
Groundwater^b		
Southgate	PCE	3 to 10
Brewery City Pizza	PCE	4 to 10
Palermo Valley	PCE	0.08 to 0.16
Total PCE in groundwater = 7 to 20 lbs		
WDOT MTL	TCE	0.04 to 0.19
Chevron	TCE	1 to 7
Southgate	TCE	1 to 8
Brewery City Pizza	TCE	5 to 13
Palermo Valley	TCE	17 to 70
Total TCE in groundwater = 24 to 98 lbs		
Soil^c		
Southgate	PCE	300
Brewery City Pizza	PCE	0.5 to 2.0
Total PCE in soil at upland action areas = 300 to 302 lbs		

^aChlorinated VOC concentration used for mass calculation based on arithmetic mean of all samples from the area for the target medium and target chlorinated VOC.

^bVolumes of contaminated groundwater based on estimated thickness of contaminated zone in area of plume in the vicinity of reference location (e.g., Southgate).

^cVolume of contaminated soil near Southgate based on areas and depths of soil containing chlorinated VOCs at concentrations greater than and less than RGs. Volume of contaminated soil near Brewery City Pizza based on areas and depths of soil containing chlorinated VOCs at concentrations greater than RGs.

Notes:

The total amount of PCE and TCE in groundwater and soil is greater than that indicated in the table because only the concentrations above RGs are included in the mass estimates.

MTL - materials testing laboratory

PCE - tetrachloroethene

RG - remediation goal

TCE - trichloroethene

VOC - volatile organic compound

WDOT - Washington State Department of Transportation

Source: URSG 1999b

8.0 DESCRIPTION OF ALTERNATIVES

It is the intent of the EPA to reduce the risk to humans and the environment to acceptable levels by meeting the RAOs identified in Section 7.2 in the design and implementation of remedial actions.

In the FS, technology types were screened to narrow the list of technologies that should be considered for more detailed evaluation. As specified by CERCLA guidance, technology types and process options were screened only on the basis of technical feasibility, with no other factors considered. Several remedial technologies, other than the alternatives described in detail later in this section, were screened out. Some examples include reductive dechlorination of groundwater (using a reactive wall) and soil vapor extraction at Chevron, Brewery City Pizza, and the WSDOT facilities.

Under CERCLA, a no-action alternative must be considered at every site to establish a baseline for comparison. In addition to the no-action alternative, five groundwater remedial action alternatives, nine surface water alternatives, and two soil alternatives were evaluated for the Palermo Wellfield Superfund Site. Some of the groundwater alternatives were broken into subalternatives and evaluated for applicability to one or more upland action areas.

8.1 GROUNDWATER

The alternatives developed for groundwater include:

- No action, consisting of no measures taken for remediation of chlorinated VOCs in groundwater
- Limited action, consisting of preventing access to groundwater containing COCs and treating groundwater at the Palermo Wellfield
- Remediation at one or more upland action areas using enhanced in situ bioremediation; treating groundwater at the Palermo Wellfield; and preventing access to groundwater containing COCs
- Plume interception by air sparging at the base of the Palermo Bluff, preventing access to untreated groundwater; treating groundwater at the Palermo Wellfield, and preventing access to groundwater containing COCs

- Remediation at one or more upland action areas using air sparging, treating groundwater at the Palermo Wellfield, and preventing access to groundwater containing COCs
- Remediation at one or more upland action areas using pump-and-treat, with discharge to the stormdrain system, treating groundwater at the Palermo Wellfield, and preventing access to groundwater containing COCs

8.1.1 Groundwater Alternative 1—No Action

This alternative is retained throughout the process of alternative development and analysis, as a baseline for comparison of other alternatives, and to help assure that unnecessary remedial action is not taken where no action is appropriate. The no-action alternative consists of allowing the site to remain in its present condition, with no measures taken to reduce or monitor COC concentrations. The no-action alternative considers the hypothetical case where the SVE system at Southgate and the Palermo Wellfield air stripping system were not installed.

8.1.2 Groundwater Alternative 2—Limited Action

Groundwater (GW) Alternative 2 consists of the following elements:

- Institutional controls
- Well water treatment at the Palermo Wellfield
- Natural attenuation
- Monitoring

This alternative would prevent access to the groundwater containing COCs; provide treatment of groundwater at the Palermo Wellfield prior to human consumption; and provide for monitoring of natural degradation mechanisms. The location of the Palermo Wellfield air strippers is shown on Figure 8-1. The technology types and process options specifically selected for this alternative are discussed in the following subsections:

Institutional Controls

Institutional controls are defined as those legal mechanisms that ensure that restrictions on land use and any engineering requirements put in place to implement the selected remedy are maintained. The identified institutional controls include deed restrictions/restrictive covenants and groundwater use restrictions. These controls may be removed in the future by petitioning the regulatory agencies and by a clear demonstration (e.g., monitoring results) that site conditions no longer warrant the particular controls.

Groundwater Use Restrictions. The FS report originally anticipated the prohibition of drilling new domestic water wells within the area of contaminated groundwater via the mechanism of a City of Tumwater ordinance. This mechanism was subsequently found to be difficult to implement and unnecessary. Because the area is fully developed and serviced by a municipal water supply, there is a low incentive for drilling near domestic water wells. Domestic use of groundwater will be prevented through a public education campaign.

Well Water Treatment

Well water at the Palermo Wellfield would be treated by the two air strippers installed in February 1999. The air strippers are designed to treat water from all of the production wells, with a capacity of 1,000 gallons per minute each. Fail-safe measures will be included to help assure that untreated water is not pumped to city supply lines.

Air stripping was selected for its effectiveness for treating TCE. Air stripping would also be effective in treating PCE and the breakdown compounds of PCE and TCE, if these compounds are present at the wellfield in the future. An ancillary benefit of air stripping is its tendency to increase pH. Regional groundwater pumped by the Palermo Wellfield exhibits characteristically low pH. Application of air stripping to all of the wells at the Palermo Wellfield will provide treatment for TCE at all wellheads, currently contaminated or not, and is also expected to increase the pH of water provided by the Palermo Wellfield.

Natural Attenuation and Monitoring

Natural attenuation is a set of intrinsic environmental processes that occur to varying degrees regardless of human intervention. As discussed in the RI, natural attenuation at the Palermo Wellfield Superfund Site appears to occur primarily by physical processes. In this alternative, periodic collection of groundwater samples from existing monitoring wells would provide monitoring of natural attenuation.

8.1.3 Groundwater Alternative 3—Action Area Remediation Using HRC™

GW Alternative 3 consists of the following elements:

- Institutional controls
- Well water treatment at the Palermo Wellfield
- Enhancement of natural biodegradation in action areas using HRC™
- Monitoring

This alternative would prevent access to the groundwater containing COCs; provide treatment of groundwater at the Palermo Wellfield prior to human consumption; and enhance and monitor natural degradation mechanisms. The elements of GW Alternative 3 are shown on Figures 8-2 and 8-3. The technology types and process options specifically selected for this alternative are discussed in the following subsections.

Institutional Controls

Institutional controls to prevent the ingestion of groundwater containing COCs would consist of those discussed under GW Alternative 2 in Section 8.1.2.

Well Water Treatment

Well water at the Palermo Wellfield would be treated by the two air strippers installed in February 1999, as discussed in Section 8.1.2.

Enhancement of Natural Biodegradation in Action Areas Using HRC™

HRC™ is a polylactate ester formulated for slow release of lactic acid upon hydration. Indigenous anaerobic microbes metabolize the lactic acid to produce hydrogen. The hydrogen can be used by reductive dehalogenators that are capable of dechlorinating TCE and PCE.

HRC™ would be emplaced at Chevron, Southgate, and Brewery City Pizza as grout backfill in drive point (GeoProbe™) holes similar to those used for soil and groundwater sample collection during the RI. Sufficient HRC™ would be used to enhance biodegradation in the action areas and for some distance downgradient. The goal would be to remediate the residual contamination in the action areas and thus prevent continued downgradient migration of COCs from these areas. Natural attenuation would continue in areas downgradient of the influence of HRC™.

HRC™ is an innovative technology and would require bench-scale and field-scale pilot testing to demonstrate effectiveness prior to full-scale implementation. One of the objectives of the field-scale pilot test would be to monitor the production and downgradient migration of daughter products such as vinyl chloride. Use of aquifer oxygenation products such as ORC™ (a sister product to HRC™ marketed by the same vendor) downgradient of the action areas may be warranted to enhance degradation of daughter products (potentially vinyl chloride) produced by enhanced biodegradation.

Monitoring

Monitoring would consist of periodic collection of groundwater samples from existing monitoring wells and new monitoring wells installed upgradient and downgradient of the HRC™ wells. Monitoring would allow assessment of the remediation effectiveness and changes in COC concentration throughout the site.

8.1.4 Groundwater Alternative 4—Plume Interception by Air Sparging

GW Alternative 4 consists of the following elements:

- Institutional controls in action areas
- Interception and treatment of groundwater containing COCs upgradient of the Palermo Wellfield using air sparging wells
- Well water treatment at the Palermo Wellfield
- Monitoring

This alternative would prevent access to the groundwater containing COCs; intercept and treat water containing COCs migrating toward the Palermo Wellfield; provide treatment of groundwater at the Palermo Wellfield prior to human consumption; and provide for monitoring of subsurface conditions. The elements of GW Alternative 4 are shown on Figures 8-4 and 8-5. The technology types and process options specifically selected for this alternative are discussed in the following subsections:

Institutional Controls

Institutional controls to prevent the ingestion of groundwater containing COCs would consist of those discussed under GW Alternative 2 in Section 8.1.2.

An access agreement or easement with the owners of the Capitol 5000 property would be required for installation of the air sparging “curtain” wells west of Rainier Avenue as described below.

Interception and Treatment of Groundwater

A line or “curtain” of vertical air sparging wells and horizontal vapor extraction piping would be constructed across the width (roughly north to south) of the plume of groundwater containing

COCs. The most likely location for the sparge curtain would be west of the Rainier Avenue residences. Air would be injected below the depth of last occurrence of COCs in groundwater, and at one or more intermediate depths to enhance treatment of the entire groundwater column. Treatment of the entire groundwater column from 0 to 130 feet bgs could eliminate the need to treat surface water collected from west of the Rainier Avenue residences. This surface water currently results from seepage of shallow groundwater and contains COCs at concentrations above the RGs for surface water.

Horizontal vapor extraction piping would recover the COC-laden sparge air. Vapor extraction would be required to prevent accumulation of vapors in nearby crawlspaces and exposures resulting from outgassing of the sparge air at the ground surface. A vapor treatment system would probably be required for treatment of the COCs prior to discharge to the atmosphere. Horizontal well sparging is a feasible alternative process option that could be reevaluated during remedial design. Installation of a deep horizontal well would probably require greater construction effort than installation of a line of vertical sparging wells. In-well stripping is not a feasible alternative process option for this location, because the very shallow groundwater is unlikely to allow proper functioning of the reinfiltration portion of the process.

Sufficient unsaturated soil thickness above the groundwater level must be provided for proper functioning of vapor extraction. Vapor extraction would have to be implemented along with a surface water alternative that drains the ponded water (the french drain described in Section 8.2). To reduce short-circuiting through the unpaved soil surface, a high-density polyethylene (HDPE) liner would have to be installed over the vapor extraction piping. The liner would be required over a large enough area to help assure that the preferential flow to the vapor extraction piping was from sparge air, rather than the ambient aboveground air. The selection of air sparging for remediation in the Palermo Valley would require treatability testing during remedial design to help assure effectiveness and allow design of the sparge air flow rate and injection pressure.

The air sparging/vapor extraction system would treat groundwater in situ, and would generate only condensate (from the vapor extraction system) for treatment and discharge. This water could be collected and periodically transported off site for disposal. Extracted soil vapors would require treatment prior to discharge to the atmosphere, as has been required for the existing soil vapor extraction system at Southgate.

Well Water Treatment

The two air strippers installed in February 1999 would be used to treat well water at the Palermo Wellfield, as discussed under GW Alternative 2 in Section 8.1.2.

Monitoring

Monitoring would consist of periodic collection of groundwater samples from existing monitoring wells, and new monitoring wells installed in the vicinity of the air sparging curtain wells. Monitoring would allow assessment of the remediation effectiveness and changes in COC concentrations throughout the site.

Monitoring would also include collection of remediation system operational data as part of ongoing operation and maintenance procedures.

8.1.5 Groundwater Alternative 5—Upland Action Area Remediation by Air Sparging

GW Alternative 5 consists of the following elements:

- In situ treatment of groundwater in upland action areas
- Institutional controls in areas underlain by groundwater containing COCs
- Well water treatment at the Palermo Wellfield
- Monitoring

This alternative would remove COCs from groundwater in the action areas; prevent access to groundwater in areas without groundwater treatment; provide treatment of groundwater at the Palermo Wellfield prior to human consumption; and provide for monitoring of subsurface conditions. The elements of GW Alternative 5 are shown on Figures 8-6 and 8-7. The technology types and process options specifically selected for this alternative are discussed in the following subsections.

In Situ Treatment of Groundwater

Based in part on the effectiveness of SVE at Southgate, the process option selected for in situ treatment of groundwater in the action areas is vertical well air sparging and SVE. These process options represent relatively simple, proven options that address both soil and groundwater in the action area. In-well stripping could be used in place of the vertical sparging wells. This alternative process option would probably require fewer wells, but of larger diameter with a more complex installation. In-well stripping might be more effective than vertical sparging wells for groundwater, but would not have the added benefit of removing chlorinated VOCs from soil (see Section 8.3 for soil remediation alternatives). Alternative process options remain available for reevaluation during remedial design. The effectiveness of air sparging in the source areas would require verification via treatability testing prior to implementation. Pilot testing would also be required to allow design of the air sparging system.

Air sparging and SVE implementation would consist of installing new systems at Chevron and Brewery City Pizza, and modifying the SVE system at Southgate to include air sparging. Three separate extraction and treatment systems would be required. Access agreements or easements would be required to allow installation and operation of remediation systems.

The air sparging/vapor extraction systems in the upland action areas would treat groundwater in situ, and would generate only condensate (from the vapor extraction system) for treatment and discharge. This water could be collected and periodically transported off site for disposal. Extracted soil vapors would require treatment prior to discharge to the atmosphere.

Well Water Treatment and Institutional Controls

Well water at the Palermo Wellfield would be treated by the two air strippers installed in February 1999, as discussed under GW Alternative 2 in Section 8.1.2. Pumping of the Palermo Wellfield wells and treatment of the pumped water by the air stripping system is expected to eventually capture and remediate the entire plume of contaminated groundwater (Section 5.5). Reduction of source area concentrations by air sparging and SVE could reduce the period of time that the wellhead air strippers are required, and reduce COC loading of the wellhead air strippers.

Groundwater containing COCs greater than RGs would remain beneath portions of the study area, even with air stripping at the wellfield and groundwater treatment at the upland action areas. An areawide restriction on well drilling would be implemented to prevent access to groundwater containing COCs, as discussed in Section 8.1.2.

Monitoring

Monitoring would include periodic collection of groundwater samples from existing monitoring wells, and from new monitoring wells installed in the vicinity of the air sparging wells at the action areas. Monitoring would allow assessment of the remediation effectiveness, and provide warning for the movement of COCs in unexpected directions as a result of air sparging.

Monitoring would also include collection of remediation system operational data as part of ongoing operation and maintenance procedures.

8.1.6 Groundwater Alternative 6—Upland Action Area Remediation by Pump and Treat

GW Alternative 6 consists of the following elements:

- Extraction and treatment of groundwater in action areas
- Institutional controls in areas underlain by groundwater containing COCs

- Discharge of treated water
- Well water treatment
- Monitoring

This alternative would remove COCs from groundwater in the upland action areas; control migration of groundwater containing COCs from the upland action areas; prevent access to groundwater in areas without groundwater treatment; provide treatment of groundwater at the Palermo Wellfield prior to human consumption; and provide for monitoring of subsurface conditions. The elements of GW Alternative 6 are shown on Figures 8-8 and 8-9. The technology types and process options specifically selected for this alternative are discussed in the following subsections.

Extraction and Treatment of Groundwater

Groundwater would be extracted and treated using air stripping at Chevron, Southgate, and Brewery City Pizza. Access agreements or easements would be required at these locations to allow system installation. Three separate extraction and treatment systems would be required. Electrical submersible pumps are the process option for groundwater recovery selected for evaluation in this alternative. Aquifer performance testing would be required to size the pumping system.

In situ treatment could be enhanced using steam injection or surfactant injection process options. These process options would require the same pump-and-treat system infrastructure, with injection as an additional element. Because adding elements to the basic pump-and-treat package will increase the system costs, this alternative assumes that pump-and-treat (with vapor extraction at Southgate) will initially be used alone. Injection can be added, if found to be advantageous, after performance of the base system is evaluated.

Discharge of Treated Water

The action-area pump-and-treat and SVE systems would generate substantial volumes of water for discharge. The only retained process option for treated water discharge is the stormdrain system. Aquifer performance testing would be required to allow estimation of the treatment system discharge rate for comparison to the stormdrain capacity.

This discharge would fall under the National Pollutant Discharge Elimination System regulations (NPDES).

Well Water Treatment and Institutional Controls

Well water at the Palermo Wellfield would be treated by the two air strippers installed in February 1999, as discussed under GW Alternative 2 in Section 8.1.2. Pumping of the Palermo Wellfield wells and treatment of the pumped water by the air stripping system is expected to eventually capture and remediate the entire plume of contaminated groundwater (Section 5.6). Reduction of source area concentrations by pump-and-treat and SVE could reduce the period of time that the wellhead air strippers are required, and reduce COC loading of the wellhead treatment system.

Groundwater containing COCs greater than RGs would remain beneath portions of the study area, even with groundwater treatment at the source areas. An areawide restriction on well drilling would be implemented to prevent access to groundwater containing COCs.

Monitoring

Monitoring would include periodic collection of groundwater samples from existing monitoring wells. Monitoring would allow assessment of the remediation effectiveness, and changes in COC concentrations throughout the site.

Monitoring would also include collection of remediation system operational data as part of ongoing operation and maintenance procedures.

8.2 SURFACE WATER/INDOOR AIR

Reducing the risk to human health from contaminants in surface water requires preventing the accumulation of vapors emitted from the surface water in Palermo neighborhood homes. In general, this could be accomplished by lowering the water table beneath the homes (which provides a soil buffer between the water and the homes) or by ventilating the crawlspaces.

The alternatives developed for reducing the risks from contaminated surface water are depicted in Figure 8-10 and listed below:

- No action, consisting of no measures taken for remediation of COCs in surface water (groundwater seepage), or for prevention of ponding of groundwater seepage
- French drain for collection of surface water; in-drain sparging aeration, consisting of treating the water collected by the french drain with a sparging system installed within the drain

- French drain for collection of surface water; lift station sparging aeration, consisting of treating water collected by the french drain with a sparging system installed in a vault at the end of the french drain
- French drain for collection of surface water; air stripping treatment of water collected by the french drain
- French drain for collection of surface water; carbon adsorption treatment of water collected by the french drain
- French drain for collection of surface water; photo-oxidation treatment of water collected by the french drain
- French drain for collection of surface water; phytoremediation applied in the area of ponding, with supplementary lift station sparging treatment of water collected by the french drain
- French drain for collection of surface water; lagoon aeration treatment of water collected by the french drain
- Crawlspace ventilation at the Rainier Avenue residences
- A combination of surface water collection and treatment and crawlspace ventilation

The process option selected for lowering the water table beneath the homes in the Feasibility Study was french drain collection, using a 600-foot long, 4-foot-deep drain. This process option is assumed for Surface Water (SW) Alternatives 2 through 8 discussed in the following subsections. A description of the selected drain is provided in the paragraphs below.

Descriptions of the surface water treatment alternatives that use the french drain are provided in subsections 8.2.1 through 8.2.8. One alternative that does not use a french drain is discussed in Section 8.2.9. A combination of SW Alternatives 8 and 9 is discussed in Section 8.2.10.

French drains consist of shallow, sloped trenches backfilled with gravel. The addition of slotted or perforated drain pipe installed along the floor of the trench significantly increases the flow rate through the drain. Drain performance and operational life can be improved by an engineered gravel backfill that acts to filter fine native sediments out of the drained water, and by wrapping the drain pipe in filter fabric. The operational life expectancy of a particular french drain is a function of the native soil type, filtering characteristics of the drain, water flow rate, drain size, and biologic activity.

To sufficiently reduce the inhalation risks, the installed drain must lower the water table below the affected homes to at least 18 inches below the soil surface beneath the homes. Based on the available data, a nominal drain depth of 4 feet is expected to result in a lateral influence extending to at least 100 feet; to discharge at an average flow rate of 80 gpm; and to result in approximately 2 feet and 1.5 feet of drawdown below average ground surface at the drain and downgradient of the drain, respectively. The 4 foot drain depth was evaluated and selected from drain depths ranging from 3 to 8 feet, using both direct solution of analytical equations, and mathematical groundwater modeling.

The actual design depth of the french drain will depend upon site-specific factors that will need to be evaluated during the remedial design phase. For example, the dewatering caused by the installed drain must be sufficient to provide 18 inches of soil between the water surface and the air in the crawlspaces. Because the ground surface is higher outside the crawlspaces than inside (the crawlspaces are below ground), the drain may need to dewater the area more than 18 inches below average ground surface. Therefore, the remedial design will include an evaluation of the actual construction of the crawlspaces.

For effective remedial design of the drain and the treatment process, design data will also have to be collected to more closely estimate the discharge from the french drain. The data collection activities could include gauging of the existing drainage ditch flow, and installation and monitoring of three to five hand-driven piezometers.

The City stormdrain invert beneath M Street begins at the existing ditch west of the Rainier Avenue residences and is approximately 5 feet bgs. For a french drain 600 feet long, sloped at 0.5 percent, and beginning at a depth of 3 feet bgs, the invert elevation of the drain at M Street would be 6 feet bgs. Therefore, discharge of the collected water will require a lift station. The lift station would consist of a utility vault equipped with an automatic pump. Electrical power (230 V) would be required to run the pump. Use of three-phase electrical power, if available in this area, would reduce operating costs. Discussions with the City indicate that it would be possible to replace the M Street stormdrain and eliminate the need for a lift station. Approximately 1,000 feet of drain would require replacement, along with all manholes along the alignment. The City estimates the total cost for drain replacement at \$30,000.

Performance monitoring of the french drain would include visual inspection of the area west of the Rainier Avenue residences to confirm the absence of ponding; estimation of the flow rate discharging from the drain; and evaluation of the area of influence of the drain. Area of influence evaluation could be accomplished by periodically recording depth to shallow groundwater in piezometers installed in the area of the drain. Piezometers could consist of driven well points, installed every 100 feet along the length of the drain. Rov's of piezometers should be installed on both sides of the drain at distances of 10, 30, 60, and 150 feet from the drain. Piezometers should

also be installed at these distances south of the south end of the drain. Piezometers should be installed prior to drain installation to collect baseline depth to water data.

8.2.1 Surface Water Alternative 1—No Action

This alternative is retained throughout the process of alternative development and analysis as a baseline for comparison of other alternatives and to help assure that unnecessary remedial action is not taken where no action is appropriate. The no-action alternative consists of allowing the site to remain in its present condition, with no measures taken to alleviate the ponding of groundwater seepage west of the Rainier Avenue residences, to reduce or monitor PCE/TCE concentrations in the surface water that results from the seepage, or to mitigate vapors emitted from the surface water.

8.2.2 Surface Water Alternative 2—In-Drain Sparging Aeration

In this alternative, sparging would occur within the pipe laid within the gravel backfill of the french drain. A series of smaller pipes would be installed within the drain pipe, providing relatively even distribution of sparge air along the entire length of the drain pipe. Water discharging from the drain would have been remediated prior to reaching the lift station. The lift station, including the pump, described in the beginning of Section 8.2 would be required for discharge to the stormdrain. Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of treated water samples, and recording of system operating parameters. The sparge air offgas is not expected to require treatment. A concept sketch of in-drain sparging is shown on Figure 8-11.

8.2.3 Surface Water Alternative 3—Lift Station Sparging Aeration

In this alternative, sparging would be applied to the water within the lift station, rather than in the drain as in SW Alternative 2. Sparge air is not provided along the entire length of the drain as the water is collected, but in a single location, with the water flow from the entire drain requiring treatment at that location. Lift-station sparging can be considered a field-constructed air stripper. Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of untreated and treated water samples, and recording of system operating parameters. The sparge air offgas is not expected to require treatment. A concept sketch of lift station sparging is shown on Figure 8-12.

8.2.4 Surface Water Alternative 4—Air Stripping

In this alternative, water intercepted by the french drain would be collected in the lift station. The lift station pump would pump the water to the air stripper, where the water would gravity flow

through the stripper trays for treatment. Treated water would gravity flow to the stormdrain. Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of untreated and treated water samples, and recording of system operating parameters. The air effluent from the air stripper is not expected to require treatment. A concept sketch of above-ground treatment alternatives such as air stripping is shown on Figure 8-13.

8.2.5 Surface Water Alternative 5—Carbon Adsorption

In this alternative, water intercepted by the french drain would be collected in the lift station. The lift station pump would pump the water through a sediment prefilter; through two carbon canisters plumbed in series; and then to the stormdrain. Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of untreated and treated water samples, and recording of system operating parameters. A concept sketch of above-ground treatment alternatives such as carbon adsorption is shown on Figure 8-13.

8.2.6 Surface Water Alternative 6—Photo-Oxidation

In this alternative, water intercepted by the french drain would be collected in the lift station. The lift station pump would pump the water through a prefilter, through the photo-oxidation unit, and then to the stormdrain. Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of untreated and treated water samples, and recording of system operating parameters. A concept sketch of above-ground treatment alternatives such as photo-oxidation is shown on Figure 8-13.

8.2.7 Surface Water Alternative 7—Phytoremediation

The success of this technology for surface water at Palermo depends on the ability of the trees to act as "organic pumps" to extract the contaminated near-surface groundwater. The trees must take up water quickly enough to control seepage and prevent ponding. A reasonable assumption is that the trees must take up water at the same rate that a french drain would drain the water. Either the trees would be placed in the location planned for the french drain, thereby replacing the drain, or the trees would be located in an engineered wetland, with the water collected by the french drain routed to the wetland.

While the pumping capacity of trees can range from 30 to 350 gallons per day per tree during summer months, the trees go dormant in winter months. Thus, the stand(s) of trees would be ineffective at controlling seepage during the season of highest precipitation in the Northwest.

To achieve uptake of the equivalent of 80 gpm from the french drain, approximately 2,900 trees would be required. Assuming a land area of 60 square feet per tree, an approximate 4-acre

planting would be required. This planting would have to be in an engineered wetland away from the current area of ponding, because only approximately 1.8 acres exist between the Rainier Avenue residences and the base of the bluff. Planting in the current area of ponding might be expected to uptake approximately 35 gpm. This uptake represents less than 50 percent of the expected drainage requirement to prevent ponding. Therefore, an additional area of planting, off site, would be required to remediate the remaining water.

Phytoremediation and Sparging Combined Alternative

A combination of a french drain with lift station sparging and phytoremediation with stands of trees at two locations is the most realistic use of phytoremediation at the subject site. The area between the Rainier Avenue residences and the base of the bluff could be planted and a french drain constructed as described in Section 8.2. The trees would uptake a portion of the shallow groundwater, with the remainder drained to the lift station with an installed lift station sparge system. From the lift station, treated water would be conveyed to an off-site engineered wetland for final treatment. The most practical means of conveyance is the existing stormdrain system, with the second stand of trees located in the area of the M Street outfall. A planting area across M Street would also be reasonable, and more land is available in this area for planting. This planting area would require installation of piping under M Street from the lift station, with the lift station pump used to transfer water to the planting area.

The lift station sparge system would be sized to completely treat the collected water, not considering the effects of phytoremediation. Sparging would be the primary treatment method while the trees matured, and would be available for use intermittently during the dormant season after the trees mature. Monitoring of phytoremediation performance could provide justification for eliminating the sparging portion of the treatment process. The trees would have to be shown to reduce water levels sufficiently during the growing season to allow recovery during the dormant season without causing ponding. The piezometer system used to monitor the effectiveness of the french drain could be used to assess the water table drawdown (see Section 8.2). Monitoring could also provide pilot test data for use of a phytoremediation wetland for future treatment of recovered groundwater.

8.2.8 Surface Water Alternative 8—Lagoon Aeration

In this alternative, water intercepted by the french drain would be collected in the lift station and pumped into the existing stormdrain beneath M Street. Treatment would occur at the M Street outfall, located at the city-owned golf course. The M Street outfall currently outlets into a "water hazard" drainage ditch on golf course property. The outfall location corresponds to the location of a sanitary sewer lift station, with an existing electrical drop and shed-sized city facility. The existing drainage ditch would be rebuilt as an engineered basin, with two surface aerators.

Monitoring would include periodic sampling of monitoring wells and piezometers, collection and analysis of untreated and treated water samples, and recording of system operating parameters.

8.2.9 Surface Water Alternative 9—Crawlspace Ventilation

The french drain would not be installed for this alternative. Instead, risks to the inhabitants of the Rainier Avenue residences would be mitigated by actively removing vapors from the crawlspaces and venting those vapors to the atmosphere. Ventilation fans and vapor collection piping similar to those used for radon mitigation would be installed in the crawlspaces of the eight affected homes along the west side of Rainier Avenue. No attempt would be made to remove the ponded water from the crawlspaces or yards.

8.2.10 Combination of Surface Water Alternatives 8 and 9

A final option considered by the FS for mitigating risks from surface water containing PCE and TCE is combining SW Alternatives 8 and 9. This combination would include collection of the ponded water using the french drain, treatment of the water using lagoon aeration, and ventilation of the crawlspaces. Ventilation would be used to remove vapors emitted through the soil surface from the near surface groundwater, while the french drain would remove ponded water, reducing vapor emissions and increasing the effectiveness of the crawlspace ventilation system.

8.3 SOIL

The alternatives developed for soil include:

- No action, consisting of taking no measures for remediation of chlorinated VOCs in soil.
- Remediation of the Southgate upland action area by soil vapor extraction for one year.
- Remediation of the Southgate upland action area by soil vapor extraction for five years.

8.3.1 Soil Alternative 1—No Action

This alternative is retained throughout the process of alternative development and analysis as a baseline for comparison of other alternatives and to help assure that unnecessary remedial action is not taken where no action is appropriate. The no-action alternative consists of allowing the site

to remain in its present condition, with no measures taken to reduce or monitor PCE/TCE concentrations. For comparison, this alternative assumes that the soil vapor extraction system at Southgate was never installed or operated.

8.3.2 Soil Alternative 2—Action Area Remediation by SVE for One Year

Soil Alternative 2 consists of using the in-situ process option of SVE. SVE is currently in use at the Southgate action area. Based on the low mass of chlorinated VOCs in soil at other action areas (see Table 5-1), all soil remediation process options for other action areas were screened out.

In this alternative, SVE would be implemented at Southgate but not implemented at any other action area for soil remediation. SVE could be used as a companion technology for groundwater alternatives 4 and 5 to collect sparge air containing chlorinated VOCs removed from groundwater. For these alternatives, applying SVE would also have the secondary effect of removing some chlorinated VOCs from unsaturated soil.

8.3.3 Soil Alternative 3—Action Area Remediation by SVE for Up To Five Years

This alternative considers the continued operation of the SVE system at Southgate beyond one year. The system would be operated until cleanup objectives are achieved or the 5-year project review.

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Figure 8-1
Palermo Wellfield
Air Stripper Locations

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Legend

- 107 ● Monitoring Well
- ⊕ Proposed Monitoring Well
- Proposed HRC[®] Injection Point
- 5001 House Number
- - - Approximate lateral extent of PCE in groundwater at concentrations greater than the RG = 5 ug/L
- - - Approximate lateral extent of TCE in groundwater at concentrations greater than the RG = 5 ug/L

Palermo Wellfield Superfund Site
Tumwater, WA
ARCS EPA
REGION 10

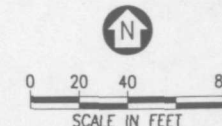
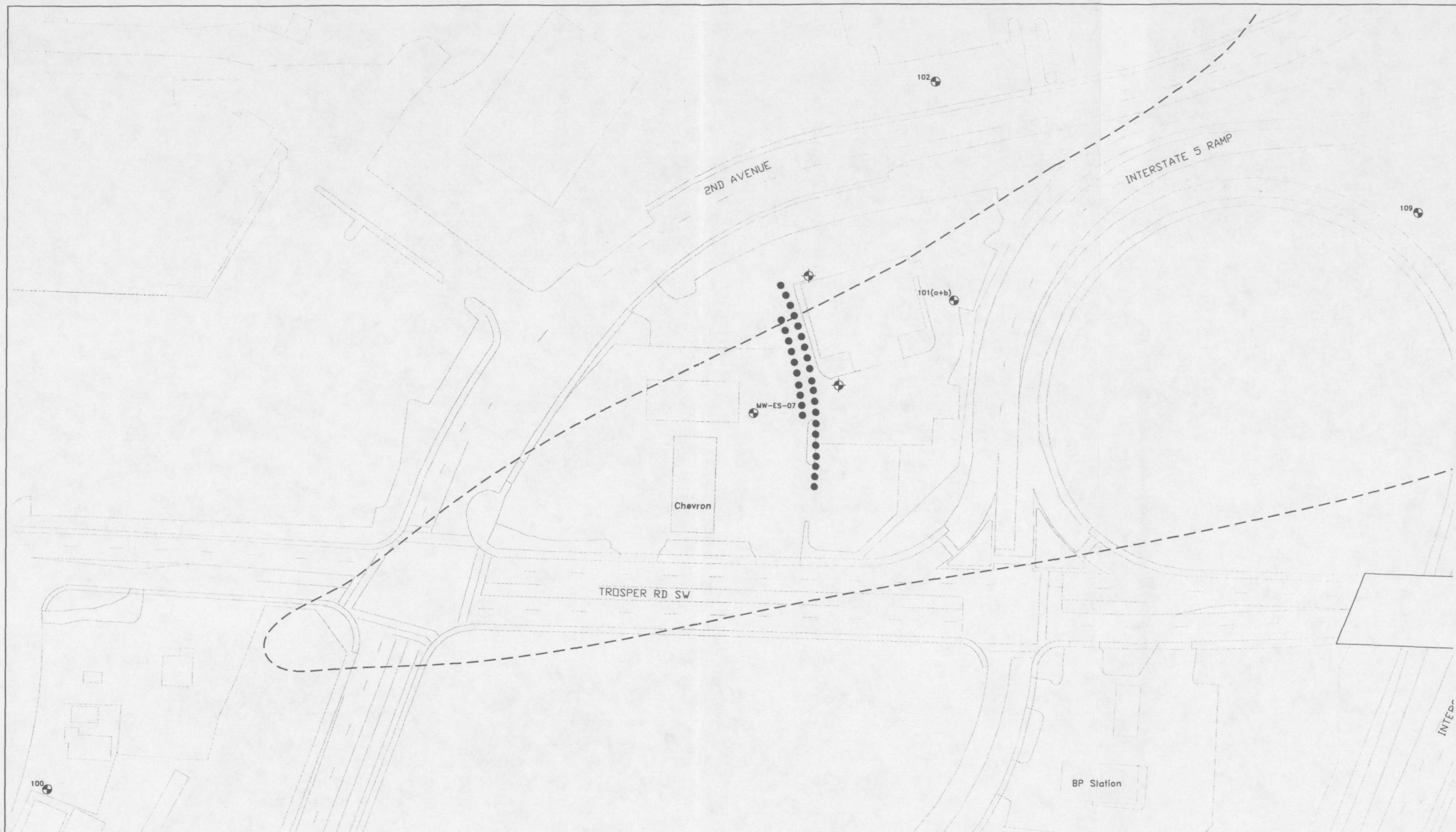


Figure 8-2
Groundwater Alternative 3:
HRC[®] Injection Point Locations
At Southgate and Brewery City Pizza

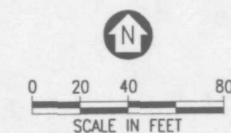
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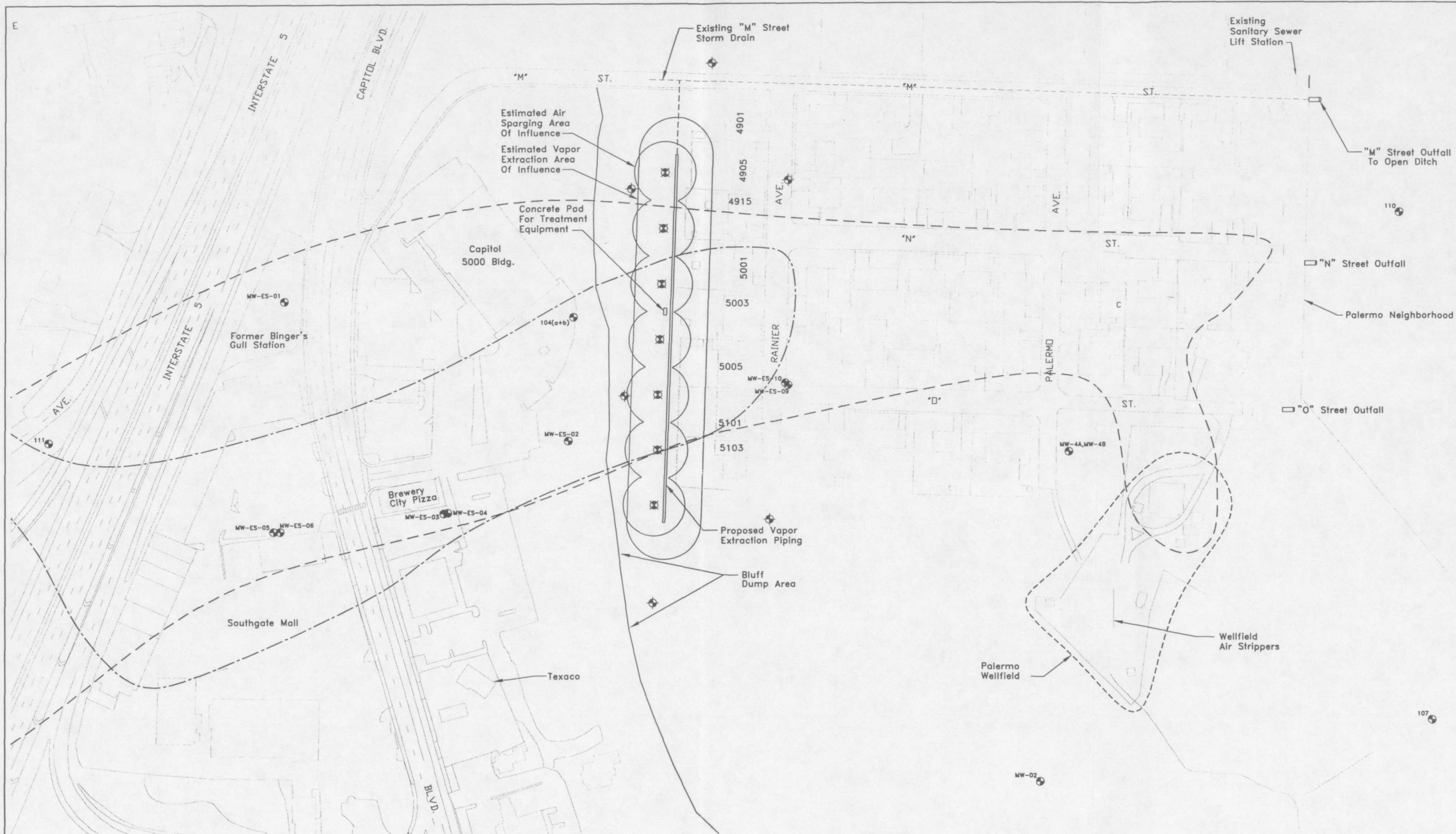
- Legend**
- 107 Monitoring Well
 - Proposed Monitoring Well
 - Proposed HRC® Injection Point
 - Approximate lateral extent of TCE in groundwater at concentrations greater than the RG = 5 ug/L

Palermo Wellfield Superfund Site
Tumwater, WA
ARCS EPA
REGION 10



URS Greiner

Figure 8-3
Groundwater Alternative 3:
HRC® Injection Locations at Chevron



- Legend**
- 107 Monitoring Well
 - Proposed Sparge Well
 - Proposed Monitoring Well
 - 5001 House Number
 - Approximate lateral extent of PCE in groundwater at concentrations greater than the RG = 5 ug/L
 - Approximate lateral extent of TCE in groundwater at concentrations greater than the RG = 5 ug/L

Palermo Wellfield Superfund Site Tumwater, WA ARCS EPA REGION 10	 SCALE IN FEET
URS Greiner	

Figure 8-4
Groundwater Alternative 4:
Treatment Component Locations

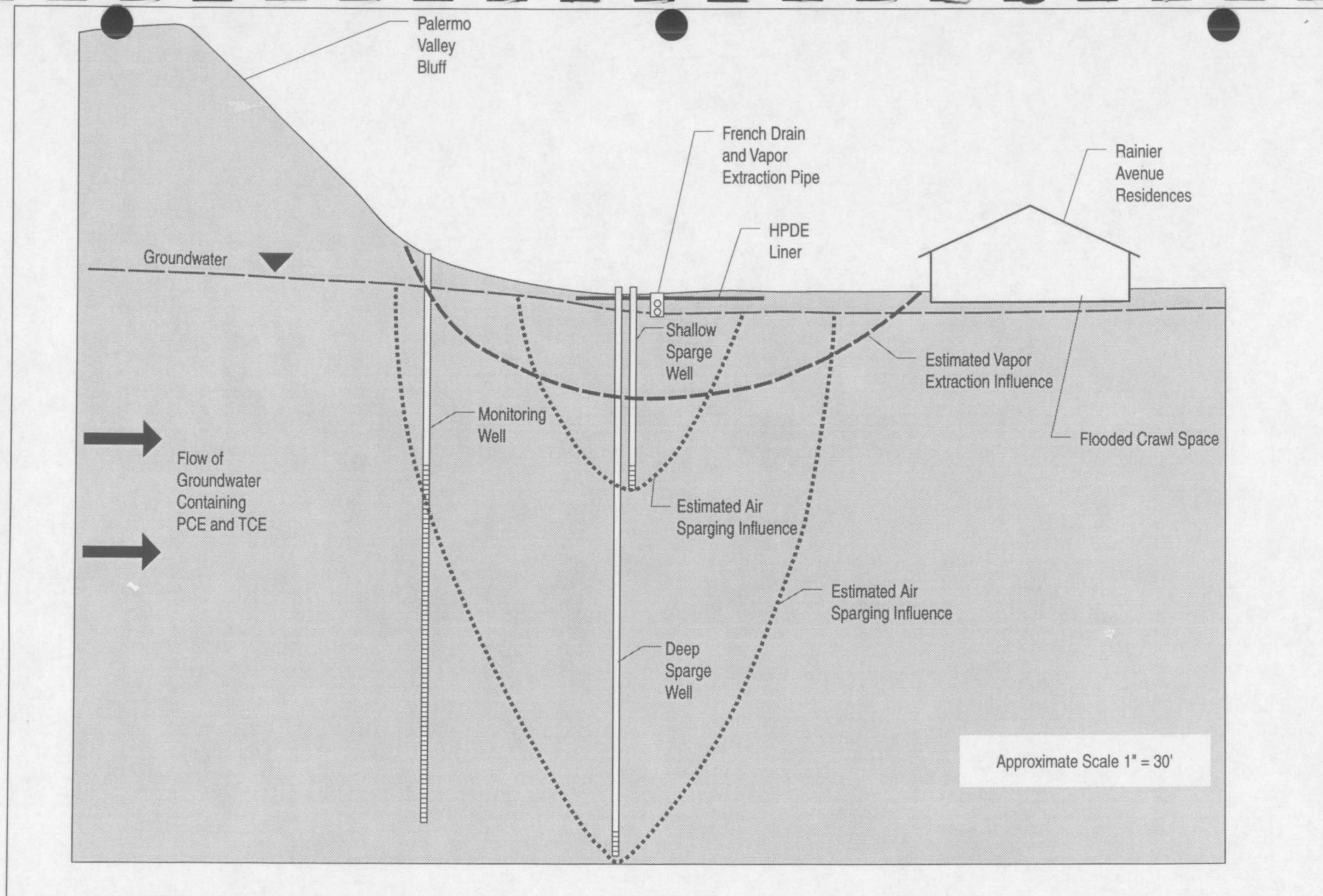


Figure 8-5
Conceptual Cross-Section of Sparge Curtain
(View to North)
Groundwater Alternative 4

ARCS EPA
REGION 10

Palermo Wellfield Superfund Site
RECORD OF DECISION

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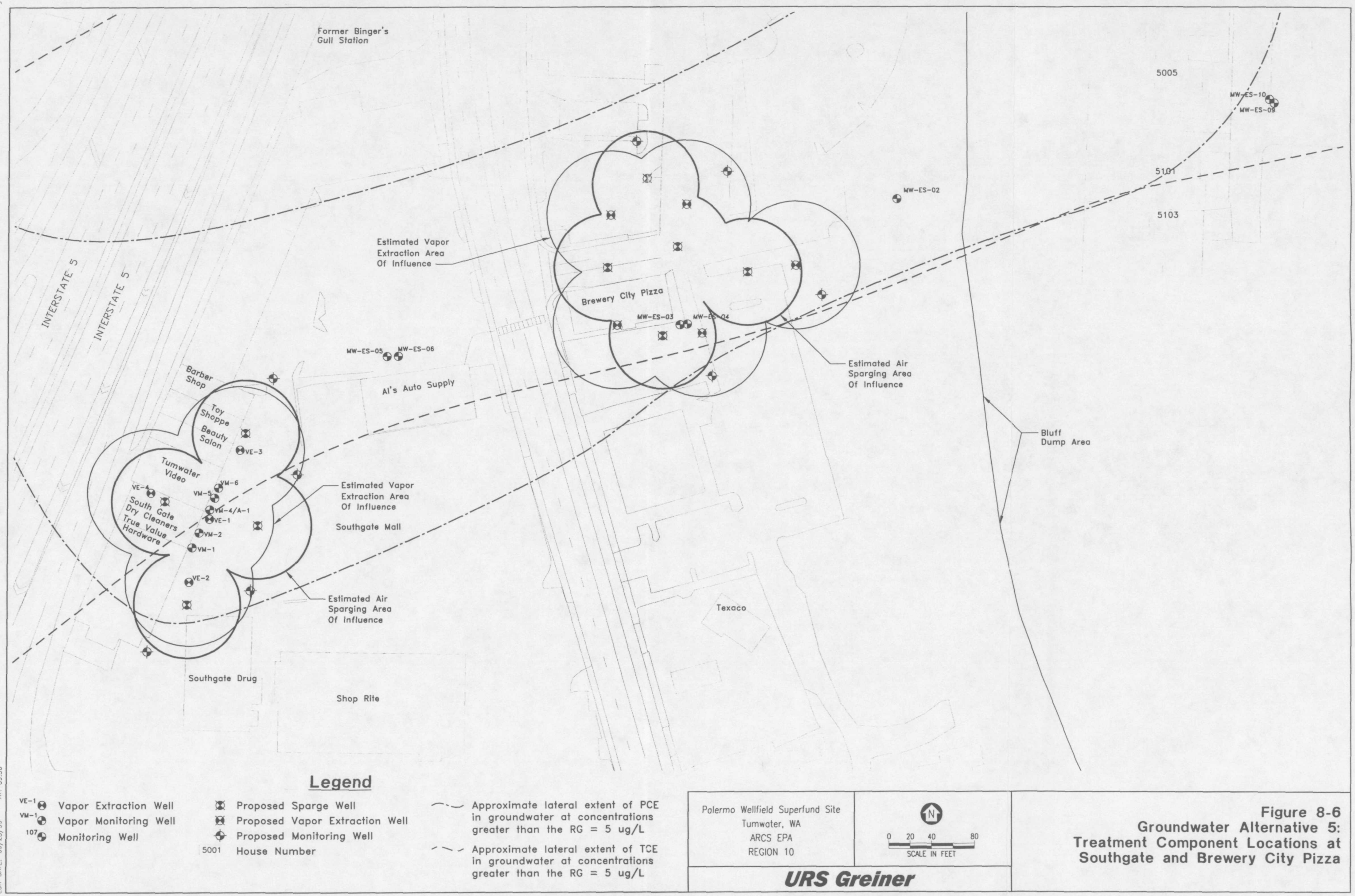
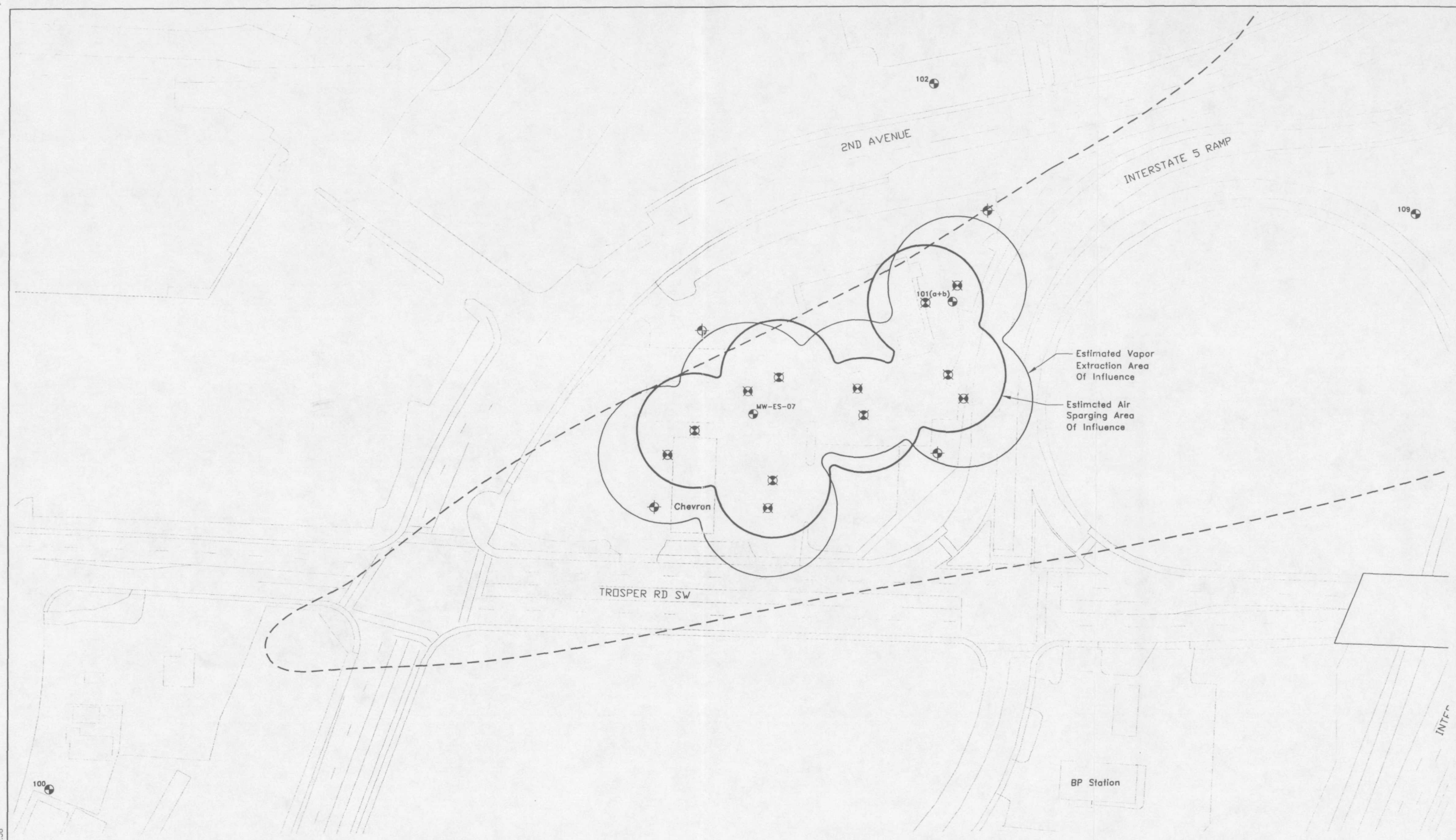


Figure 8-6
Groundwater Alternative 5:
Treatment Component Locations at
Southgate and Brewery City Pizza

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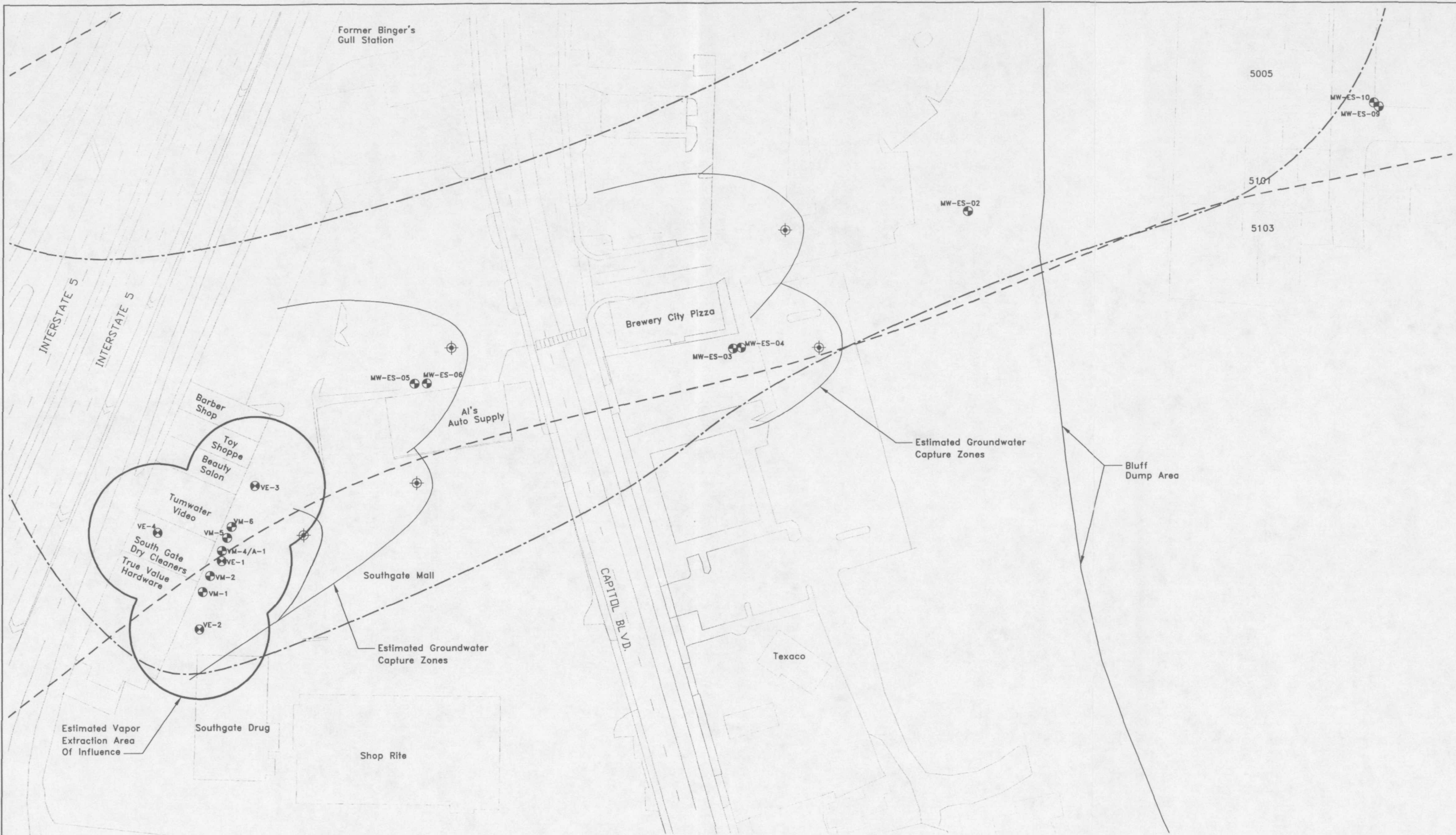
Legend

- 107 Monitoring Well
- 108 Proposed Sparge Well
- 109 Proposed Monitoring Well
- 110 Proposed Vapor Extraction Well
- 111 Approximate lateral extent of TCE in groundwater at concentrations greater than the RG = 5 ug/L

Palermo Wellfield Superfund Site Tumwater, WA ARCS EPA REGION 10	 0 20 40 80 SCALE IN FEET
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URS Greiner

Figure 8-7
Groundwater Alternative 5:
Treatment Component Locations at
Chevron



Legend

5001 House Number
 107 Monitoring Well

VM-1 Vapor Monitoring Well
 VE-1 Vapor Extraction Well
 Proposed Groundwater Recovery Well

Approximate lateral extent of PCE in groundwater at concentrations greater than the RG = 5 ug/L
 Approximate lateral extent of TCE in groundwater at concentrations greater than the RG = 5 ug/L

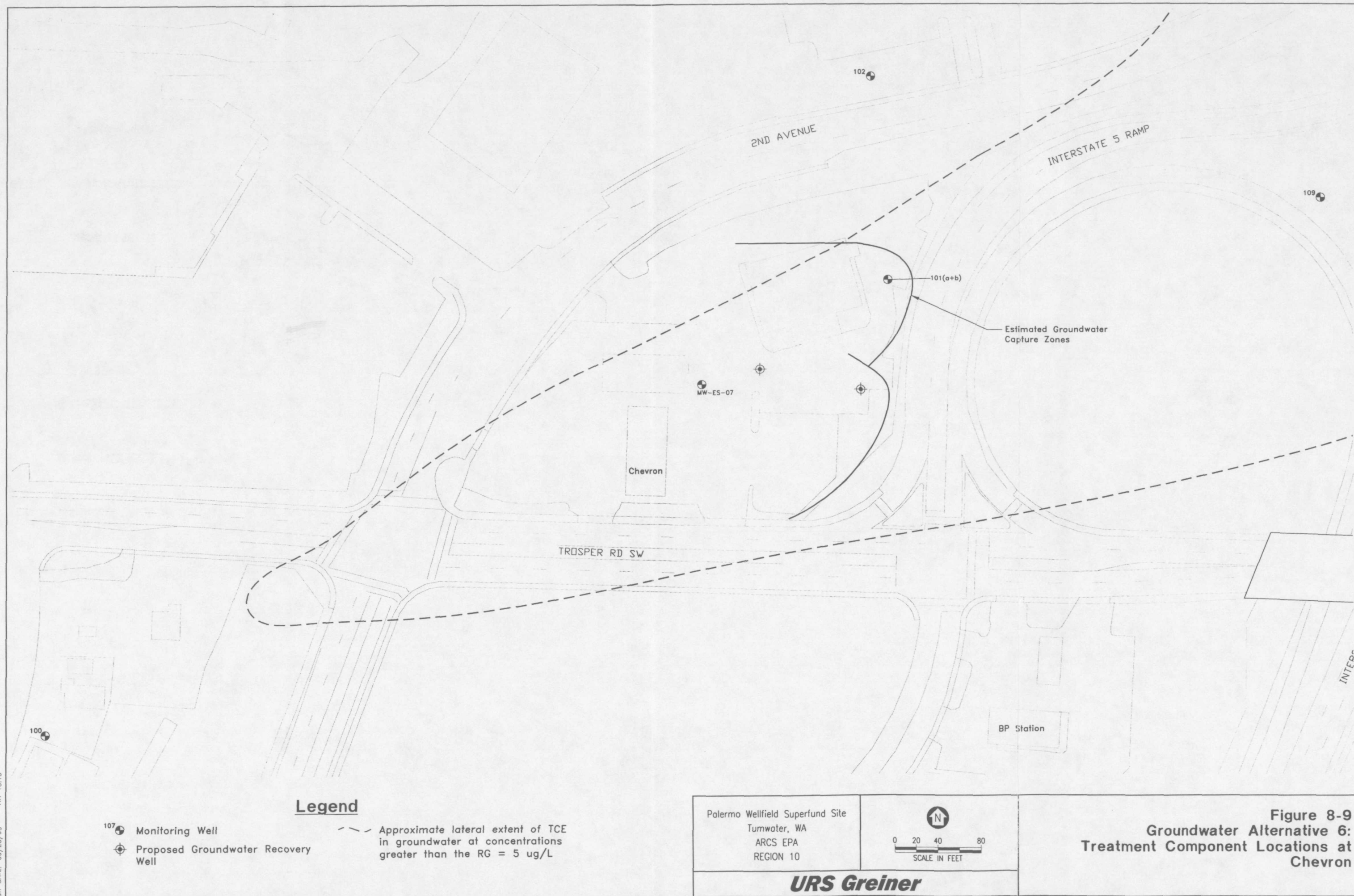
Palermo Wellfield Superfund Site
 Tumwater, WA
 ARCS EPA
 REGION 10

0 20 40 80
 SCALE IN FEET

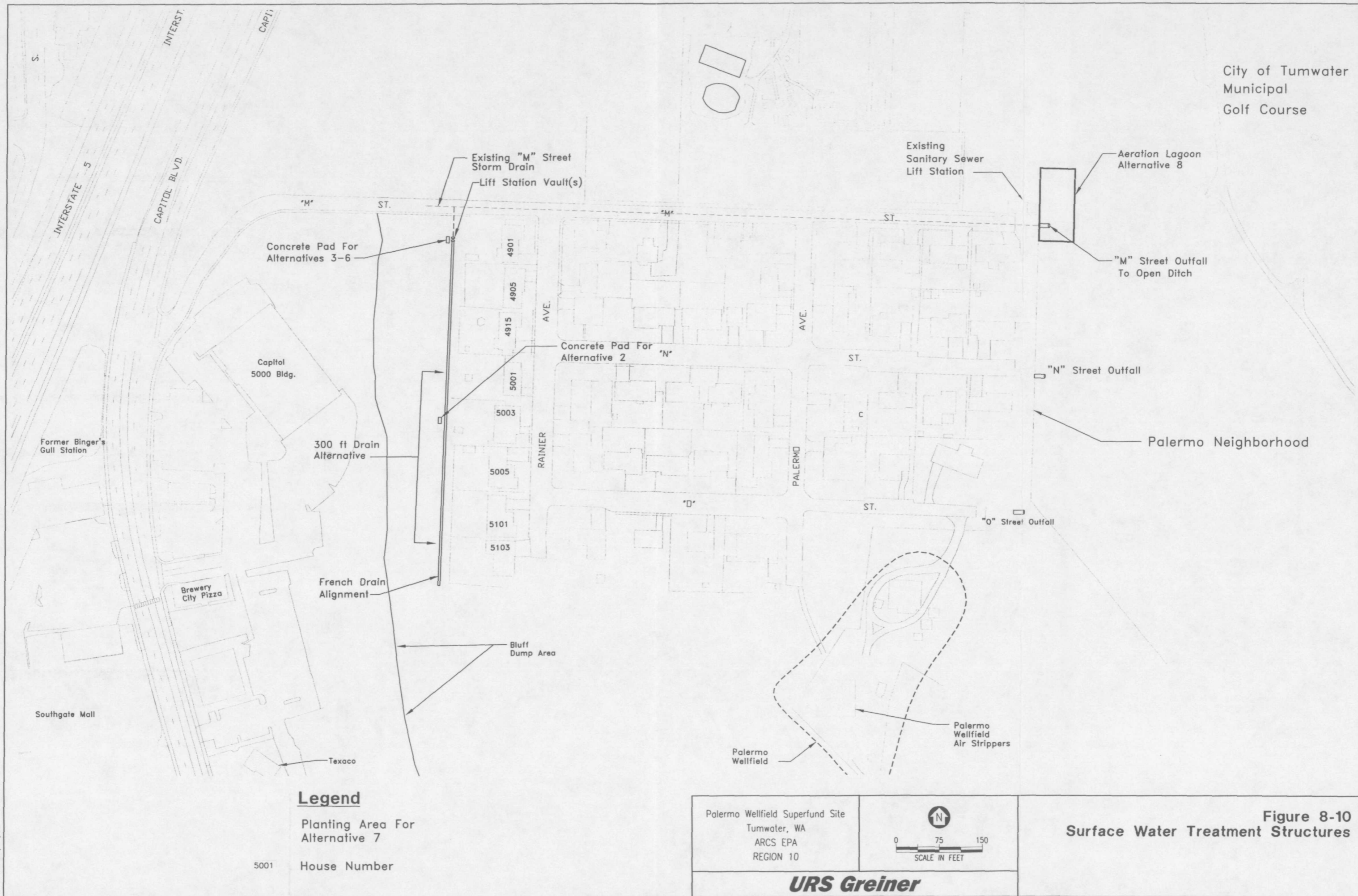
URS Greiner

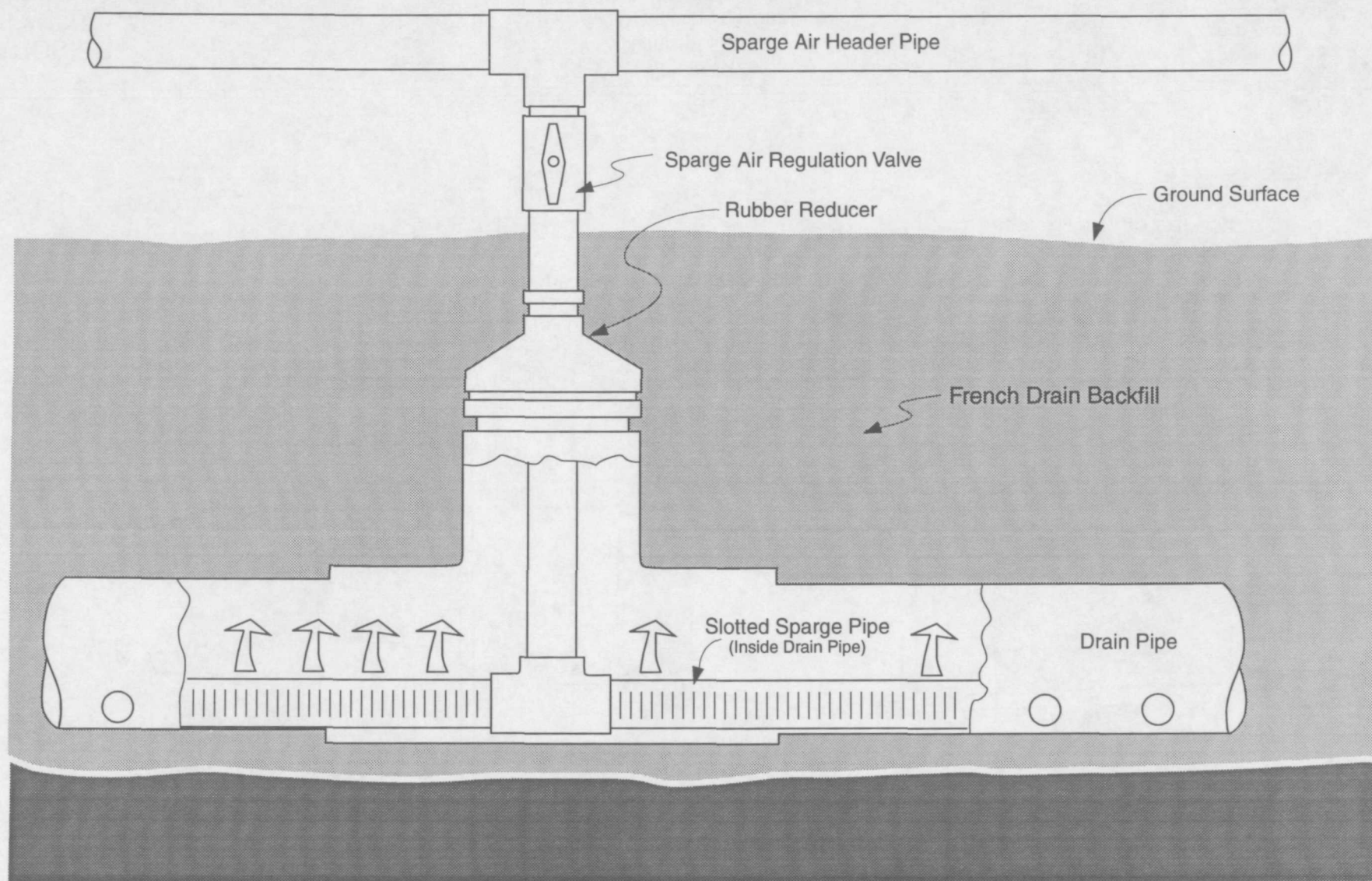
Figure 8-8
Groundwater Alternative 6:
Treatment Component Locations at
Southgate and Brewery City Pizza

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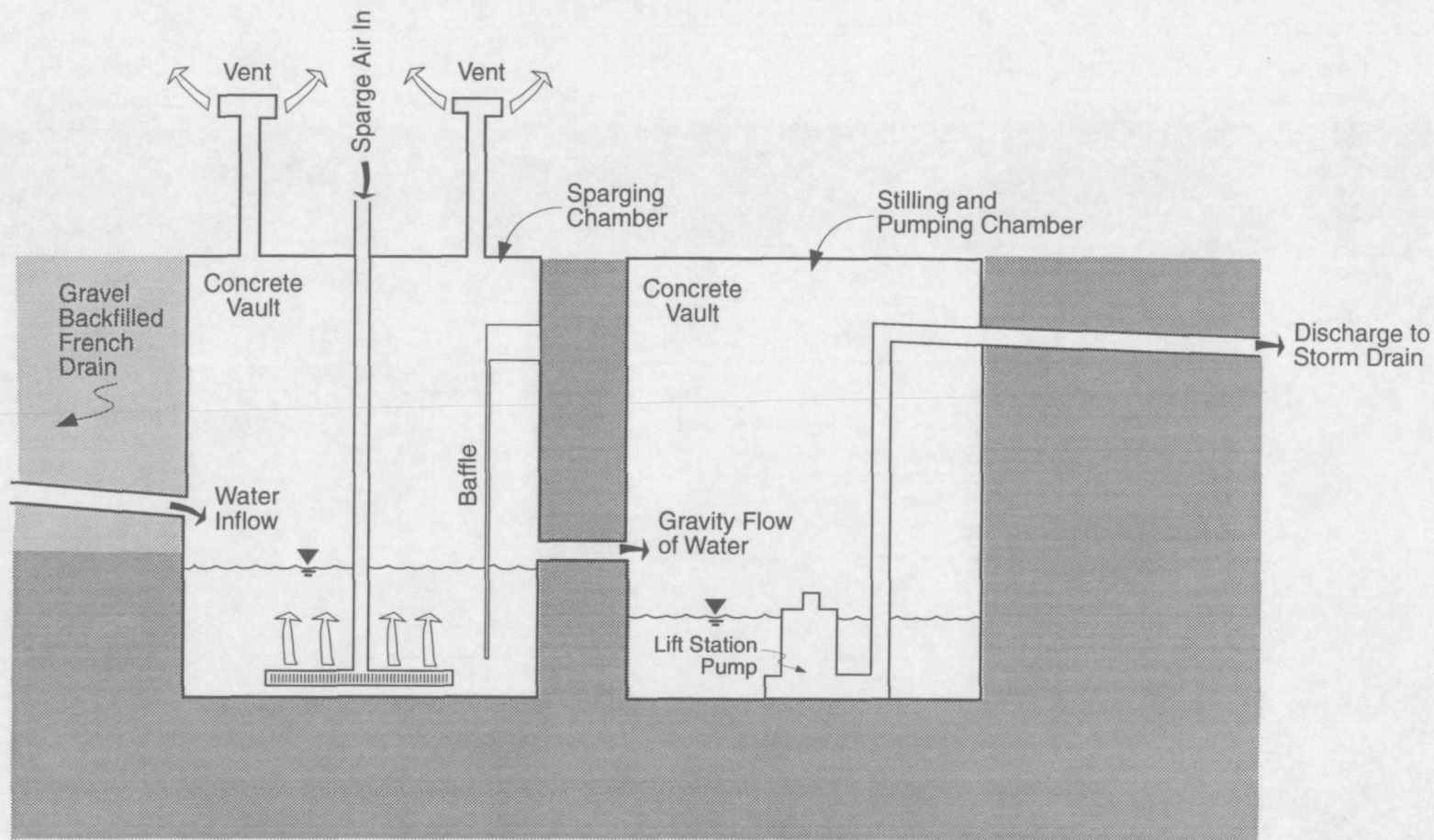


Cross Section View
Approximate Scale 1" = 6"

ARCS EPA
REGION 10

Figure 8-11
Concept Sketch
In-Drain Sparging
Surface Water Alternative 2

Palermo Wellfield Superfund Site
RECORD OF DECISION

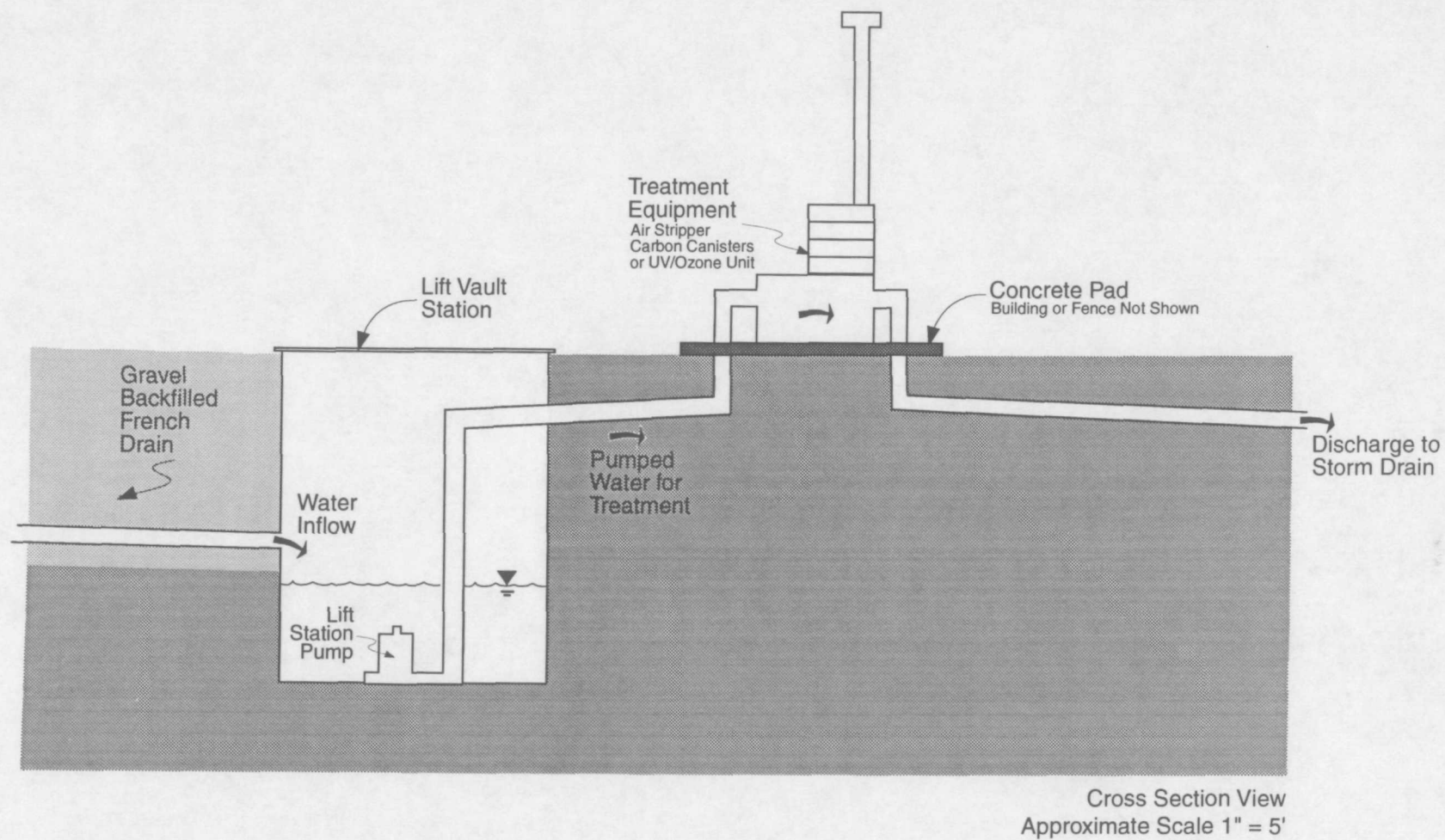


Cross Section View
Approximate Scale 1" = 4'

ARCS EPA
REGION 10

Figure 8-12
Concept Sketch
Lift Station Sparging
Surface Water Alternative 3

Palermo Wellfield Superfund Site
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Figure 8-13
Concept Sketch
Above Ground Treatment
Surface Water Alternatives 4-6

Palermo Wellfield Superfund Site
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9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The EPA has established nine criteria for the evaluation of remedial alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The following subsections evaluate the alternatives for groundwater, surface water, and soil according to the nine EPA evaluation criteria. The comparison of alternatives is summarized in Tables 9-1 through 9-3. Each remedial alternative is discussed in terms of the evaluation criteria to help identify a preferred alternative for the Palermo Wellfield Superfund Site. The no-action alternative (Alternative 1) for each medium was included as a baseline comparison.

9.1 GROUNDWATER

9.1.1 Overall Protection of Human Health and the Environment

All of the groundwater alternatives except GW Alternative 1 (no action) were developed to satisfy all the RAOs for groundwater. Therefore, GW Alternatives 2 through 6 offer good overall protection of human health and the environment. All of the action alternatives would leave some COCs in groundwater for several years, necessitating a five-year review.

The no-action alternative would not reduce future risks to human health and the environment. Current risks would also exist in the absence of wellhead air stripping. The risks are not likely to decrease by natural processes in the near future, and risks may increase as groundwater containing COCs continues to migrate downgradient toward additional receptors.

GW Alternative 2 limited action would provide protection of human health and the environment as long as the institutional controls, treatment components, and monitoring program were maintained. Monitoring could conceivably reveal changes to the plume of COCs in groundwater

indicating potential new impacts to downgradient receptors such as the Deschutes River, unimpacted Palermo Wellfield wells, and the Pabst Brewery Wellfield to the northeast. Such new impacts could include daylighting of contaminated groundwater at the river, increased COC concentrations at the Palermo Wellfield, detection of PCE at the Palermo Wellfield, or detection of COCs in Palermo Wellfield or brewery wells that are currently unimpacted. Mathematical modeling performed during the RI indicates, however, that pumping of the Palermo Wellfield wells at current (or higher) flow rates will maintain capture of the contaminant plume. The air stripping system installed at the Palermo Wellfield was designed with consideration of possible contaminant concentration increases and the possible future detection of PCE at the wellheads. With capture of the plume by the Palermo Wellfield, GW Alternative 2 would protect human health and the environment, eventually remediating the entire site.

Air stripping at the Palermo Wellfield is being implemented under EPA's removal program. Because wellhead treatment is already being implemented, it has been included as part of all groundwater alternatives except Alternative 1, no action. Air stripping is being implemented to address COCs present in groundwater at the Palermo Wellfield. An additional benefit of selecting air stripping for treatment at the Palermo Wellfield is its tendency to favorably adjust the pH of the water (which facilitates compliance with EPA's corrosivity rule). Alternatives that reduce COCs upgradient of the wellhead may eventually make treatment of well water to remove COCs unnecessary.

GW Alternative 3, HRC™ in upland action areas consists of all of the elements of GW Alternative 2 plus enhancement of biodegradation in upland action areas. If the biodegradation enhancement is effective, GW Alternative 3 could result in a more rapid reduction of COCs in the upland action areas and thereby throughout the site. This would add an additional factor of safety against failure of institutional controls or wellhead treatment components, and shorten the time that these other components were required. GW Alternative 3 could increase the production of daughter products such as vinyl chloride.

GW Alternative 4, air sparging interception, would result in a shorter remediation time than GW Alternative 2. Remediation of groundwater as it migrates past Rainier Avenue would provide additional protection to all downgradient receptors. Groundwater containing COCs currently downgradient of Rainier Avenue would continue migrating, to be captured at the Palermo Wellfield. GW Alternative 4 is probably more protective than GW Alternative 3, because it relies on proven technology to remove COCs from groundwater. GW Alternative 4 would also treat shallow groundwater at the base of the Palermo Bluff before it daylights as surface water. Implementation of GW Alternative 4 runs the risk of increasing COC vapors in the crawlspaces of the Rainier Avenue residences.

GW Alternative 5, air sparging in upland action areas, would also result in a shorter remediation time than GW Alternatives 2 and 3. Active remediation using a proven technology in the upland action areas reduces the reliance on maintenance of institutional controls to reduce risk. Reduction of COCs in upland action areas should shorten the time required for natural attenuation of the plume between the upland action areas and the Palermo Wellfield.

The active remediation in GW Alternative 5 would occur at a greater distance from downgradient receptors. Therefore, more time would be required for noticeable effects of Alternative 5 at these receptors, as compared to GW Alternative 4. In addition, Alternative 5 is focused on specific upland action areas, rather than the entire plume cross-section as in Alternative 4. Therefore, if additional, unidentified, sources exist, or if COCs have accumulated in some area other than the identified sources, GW Alternative 5 would provide less comprehensive protection of downgradient receptors than GW Alternative 4.

GW Alternative 6, pump-and-treat in upland action areas, would provide a level of protection similar to GW Alternative 5. Because groundwater would be captured, extracted, and treated, GW Alternative 6 could be more effective than GW Alternative 5 at removing COCs and reducing the time required for natural attenuation downgradient. GW Alternative 6 would also prevent migration of groundwater containing COCs from within the capture zone, adding to the protection of downgradient receptors. Otherwise, GW Alternative 6 has the same limitations as GW Alternative 5 with respect to noticeable effects at downgradient receptors, and protection of those receptors.

9.1.2 Compliance With ARARs

Under GW Alternative 1, no actions would be taken to mitigate or monitor current or future ARAR exceedances. Under GW Alternative 2, current chemical-specific ARAR exceedances throughout the aquifer would be mitigated over time, as COCs in soil and groundwater are subjected to natural attenuation processes and contaminated groundwater is captured and treated at the Palermo Wellfield. ARARs at the current point of exposure (wellheads at the Palermo Wellfield) would be met by the wellhead air strippers. Monitoring would allow recognition of future ARAR exceedances (such as detection of COCs downgradient of current COC areal extent limits) and further action as necessary.

GW Alternatives 3 through 6 would achieve compliance with ARARs, probably in less time than GW Alternative 2. Compliance with chemical-specific ARARs throughout the aquifer still would require several years, as migrating COCs are treated in specific areas, and untreated COCs are subjected to natural attenuation processes. Because contaminants will have been left on site, a five-year review would be required.

Alternative 2 could require 15 years or more to achieve compliance with ARARs. Based on comparison to Alternative 2, Alternative 3 could achieve compliance with ARARs in 8 to 11 years. Alternative 4 could achieve compliance with ARARs in 3 years. Alternative 5 could achieve compliance with ARARs in 4 to 14 years. Alternative 6 could achieve compliance with ARARs in 2 to 8 years.

It is not feasible to actively capture and treat all of the groundwater containing COCs in a short time. Because of this, compliance with chemical-specific ARARs throughout the aquifer for all of the alternatives depends to a greater or lesser extent on natural attenuation. All of the alternatives rely on natural attenuation for compliance with ARARs in areas without active remediation. However, the wellhead air strippers implemented under GW Alternatives 2 through 6 achieve ARAR compliance at the current point of exposure and will eventually do so throughout the site. Because of the persistence of PCE and TCE in the environment and the large area of impact, compliance with chemical-specific ARARs throughout the aquifer under any of the proposed alternatives is expected to require years or decades.

9.1.3 Long-Term Effectiveness and Permanence

The no-action alternative for groundwater is not expected to be effective. Future risks would not be mitigated, and impacts could increase over time as COCs migrate toward the Pabst Brewery wells and the Deschutes River.

All of the action groundwater alternatives (2 through 6) achieve compliance with ARARs at the current point of exposure through air stripping at the Palermo Wellfield wellheads. Residual contamination remaining in the groundwater upgradient of the Palermo Wellfield following implementation of air stripping is remediated by each of the action alternatives, with the time to achieve RGs varying between alternatives. Some alternatives also generate waste streams of treated vapor or water (or both) that have the potential to contain residual chlorinated VOC concentrations.

GW Alternative 2 would result in the highest concentrations and longest persistence of residual COCs in groundwater beneath the site, because natural attenuation processes appear to operate slowly at the site. GW Alternative 2 uses the least amount of remediation equipment, which facilitates long-term maintenance. GW Alternative 2 relies on institutional controls, which can be difficult to enforce over several decades.

GW Alternative 3 could speed the natural biodegradation process relied upon in Alternative 2, thus reducing the long-term reliance on institutional controls. Enhanced biodegradation would result in lower residual concentrations of COCs. Because this enhancement is achieved using a passive chemical process, the operation, maintenance, and monitoring efforts are low compared to

equipment-intensive remediation. The technology used in GW Alternative 3 is unproven, however, and may not be effective. The technology may also increase the production of toxic daughter products.

GW Alternative 4 would more actively remove COCs from groundwater, and therefore lower residual COC concentrations faster than GW Alternative 2. The technology used has a longer operational history than that for GW Alternative 3, and may be more effective. GW Alternative 4 uses more complex equipment, however, which would require maintenance and eventual replacement.

GW Alternatives 5 and 6 require more complex equipment than GW Alternative 4 and would require correspondingly more maintenance and equipment replacement. GW Alternatives 5 and 6 rely less on institutional controls than GW Alternatives 2 and 4, and so entail fewer concerns regarding long-term enforcement.

9.1.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

GW Alternative 6 would result in the greatest rate of reduction in volume through treatment, of the five alternatives evaluated. However, all of the alternatives would eventually treat the entire contaminated volume of groundwater. GW Alternative 6 would capture and treat groundwater near the upgradient areas and capture and treat groundwater at the Palermo Wellfield. This alternative is expected to remove the largest chlorinated VOC mass because it moves large volumes of groundwater to collection and treatment locations, rather than passively treating groundwater already in the vicinity of treatment wells. The groundwater capture component of GW Alternative 6 also makes this one of the superior alternatives for reducing COC mobility.

All of the action alternatives for groundwater utilize air stripping to treat groundwater pumped at the Palermo Wellfield. Because of the large volume of groundwater pumped, this treatment component is expected to remove a significant mass of chlorinated VOC when compared to other components and alternatives. Pumping and treating groundwater at the Palermo Wellfield is expected to remove more chlorinated VOC mass than any other component or alternative except for pump-and-treat at the action areas (GW Alternative 6).

GW Alternative 4 would result in the greatest reduction of COC mobility, because it establishes a barrier to COC migration. If currently unknown areas of high residual contamination exist in the uplands area, GW Alternative 4 would protect against migration of COCs from these areas to downgradient receptors. GW Alternatives that target currently identified upland action areas would not be as protective in such a case. GW Alternative 4 is also one of the better alternatives for reducing COC volume, because relatively high concentrations of COCs in groundwater currently exist at the base of the bluff. GW Alternative 4 would not directly reduce COC volume

in upland action areas, however. Therefore, once the chlorinated VOC mass in the immediate vicinity of the sparge curtain is removed, the system will remove chlorinated VOC only at the rate it is transported from upgradient areas.

GW Alternative 3 would potentially result in the fastest reduction in toxicity, by enhancing the biodegradation of PCE and TCE. In the short term, and in local areas, toxicity could be increased by GW Alternative 3, as toxic daughter products are created by the biodegradation process. GW Alternative 3 would not directly reduce COC volume or mobility.

GW Alternative 5 treats groundwater in the upland action areas, but does not capture groundwater. GW Alternative 5 therefore is less effective than GW Alternative 6 at reducing COC mobility. GW Alternative 5 is also expected to be less effective at reducing chlorinated VOC volume, because it treats groundwater within the area of sparging without capturing groundwater. Groundwater containing COCs enters the area of remediation only by natural groundwater movement.

GW Alternative 2 would be the slowest (of the action alternatives) at reducing toxicity, mobility, and volume of COCs, because treatment would occur only at the Palermo Wellfield. However, GW Alternative 2 would ultimately lead to the same reductions as the other action alternatives.

The no-action alternative for groundwater would not reduce toxicity, mobility, and volume of COCs, except through natural degradation processes, which would not be monitored.

9.1.5 Short-Term Effectiveness

The no-action alternative would not cause any short-term risks or impacts to the nearby community, workers, or environment, but is not expected to satisfy RAOs. The current risks would remain.

GW Alternatives 2 through 6 would all cause some nuisance noise and inconvenience to the community from construction activities. Workers, the community, and the environment could be protected using standard construction and hazardous site health and safety techniques.

The effectiveness of all of the action groundwater alternatives (2 through 6) with regard to complying with ARARs at the current point of exposure (Palermo Wellfield wellheads) is equal. All of these alternatives utilize the air stripping system constructed at the Palermo Wellfield. Differences in effectiveness between alternatives result from approaches for remediating residual COC concentrations in groundwater upgradient of the Palermo Wellfield.

All of the active remediation measures proposed in GW Alternatives 2, 4, 5, and 6 would begin to be effective immediately after startup, with effectiveness increasing with time as the remediation improves groundwater quality downgradient of the area of remediation. GW Alternative 3 would require several months for acclimation of the bacteria in the subsurface.

9.1.6 Implementability

The no-action alternative is the easiest to implement. All other groundwater alternatives include installation of the wellhead air strippers. Therefore, implementability based upon this component is equal among GW Alternatives 2 through 6. GW Alternative 2 is the next easiest to implement after the no-action alternative. GW Alternative 2 includes no active remedial measures beyond those common to GW Alternatives 2 through 6.

GW Alternatives 3 through 6 require pilot testing prior to design, with the pilot tests of approximately equal complexity. The pilot test for GW Alternative 3 is not particularly difficult, but requires a longer timeframe than pilot tests for the other alternatives because it requires monitoring of the effects of biodegradation over time.

GW Alternatives 5 and 6 are more difficult to install and maintain than GW Alternatives 3 and 4, because:

- Three treatment systems are required
- More wells are required
- The wells are distributed over a wider area at multiple locations
- Wells and treatment equipment are located on multiple, developed private properties that are in use

GW Alternative 6 is more difficult to install and maintain than GW Alternative 5 because aboveground groundwater treatment components are included in the remediation system, requiring more controls and equipment.

All of the alternatives that rely on air sparging are difficult to implement because of the depth of contamination, the large contaminated saturated thickness, and the relatively low concentrations of COCs. These factors require large air compressors with high power consumption and require three-phase power. Careful design and monitoring is required to help ensure that contaminated vapors do not escape the vapor recovery systems and that chlorinated VOC mobility is not enhanced.

The pump-and-treat alternative may be difficult to implement because of potentially high volumes of discharge water that must go to the stormdrain system. The capacity of the stormdrain system could be a limiting factor. In addition, capturing groundwater across a large saturated thickness poses design problems for well construction and depth of well pump placement.

9.1.7 Cost

Costs for each of the groundwater alternatives are summarized in Table 9-1. Subalternatives shown in Table 9-1 for GW Alternatives 3, 5, and 6 present costs for application of each of these alternatives at one of the three upland action areas.

Aside from the no-action alternative, GW Alternative 2 is the least expensive alternative. Costs are primarily associated with the wellhead air stripping system, which is common to all action alternatives. Additional costs for GW Alternative 2 are for procuring institutional controls and long-term monitoring of site conditions.

Upland action area remediation by HRC™ (GW Alternative 3) is the most expensive alternative, primarily because of the assumption that fresh product would have to be emplaced annually.

Plume interception by air sparging (GW Alternative 4) is the median total-cost alternative. This alternative assumes a moderate number of new wells, a compact remedial equipment installation, and an expected moderate level of carbon usage for offgas treatment.

Upland action area remediation by pump-and-treat (GW Alternative 6) is slightly less expensive than upland action area remediation by air sparging (GW Alternative 5). This cost difference is primarily the result of the assumed higher concentrations of COCs in the SVE vapor stream when air sparging is used. These higher concentrations result in a higher carbon usage rate. Essentially, COCs are being treated using vapor-phase carbon in GW Alternative 5, and by air stripping in GW Alternative 6. Assuming no offgas treatment is required for the air stripper, air stripping is the less expensive option. More precise estimation of the extracted vapor concentrations in GW Alternatives 5 and 6 would require pilot testing. Because GW Alternative 6 captures groundwater to be treated, it treats higher volumes of groundwater than GW Alternative 5.

The air sparging option also assumes the installation of more SVE and sparge wells than the pump-and-treat option assumes the installation of pumping wells. This is primarily because the pump-and-treat option utilizes groundwater flow and drawdown to recover chlorinated VOCs, whereas sparging wells must be placed throughout the target area.

9.1.8 State Acceptance

Ecology has been involved with the development and review of the RI, FS, proposed plan, and ROD. Ecology's participation has resulted in substantive changes to these documents. Ecology concurs with the selection of GW Alternative 2 for groundwater at the Palermo Wellfield Superfund Site.

9.1.9 Community Acceptance

A responsiveness summary of the comments is provided in Appendix A of this document.

The issues regarding groundwater that were discussed during the public meeting and in subsequent written comments included:

- The extent, frequency, and timing of groundwater sampling prior to and during the RI
- The past and current understanding of groundwater and contaminant movement
- The extent and frequency of future groundwater sampling
- Identification of sources of contamination

None of the issues identified resulted in changes to the preferred alternative for groundwater.

9.2 SURFACE WATER

9.2.1 Overall Protection of Human Health and the Environment

All of the surface water alternatives except SW Alternatives 1 (no action) and 9 (crawlspace ventilation) were developed to satisfy all the remedial action objectives (RAOs) for surface water, and therefore SW Alternatives 2 through 8 offer good overall protection of human health and the environment. SW Alternative 9 was developed to specifically address the RAO for inhalation of vapors and does not prevent discharge of groundwater containing COCs to surface water.

The no-action alternative for surface water would not reduce current and future risks to human health and the environment. Near-surface groundwater containing COCs would continue to daylight as surface water at the base of the Palermo Bluff, where exposure to the public occurs.

SW Alternatives 2 through 8 offer similar levels of protection of human health and the environment. Except for SW Alternative 8, the alternatives collect and treat water containing COCs in the location where current exposure occurs (in the area of the Rainier Avenue residences). SW Alternatives 2 through 7 use differing methods to achieve protection, but offer very similar levels of protection.

SW Alternative 8 conveys collected water containing COCs through a portion of the stormdrain system to a remote treatment location (the proposed lagoon at the golf course). Because the proposed french drain collection mechanism used to collect this water would be more effective than the current ditch system, the water collected is likely to be higher in volume, and may contain higher concentrations of COCs (as compared to the water currently conveyed through the M Street stormdrain).

Comparison of the excess cancer risk reduction expected from implementation of SW Alternatives 8, 9, and a combination of 8 and 9 indicates that both SW Alternative 8 and the combination of SW Alternatives 8 and 9 achieve compliance with ARARs. SW Alternative 9, if implemented alone, would not sufficiently reduce risks to human health.

9.2.2 Compliance with ARARs

All of the surface water alternatives except SW Alternatives 1 (no action) and 9 (crawl space ventilation) would comply with chemical-, location-, and action-specific ARARs. SW Alternatives 2, 3, 4, 7, 8, and 9 would require compliance with action-specific air discharge ARARs that would not apply to SW Alternatives 5 and 6. SW Alternatives 5 and 7 would generate potentially hazardous waste (spent carbon and tree tissues, respectively) that could require disposal according to hazardous waste ARARs. All of the alternatives except 1 and 9 would require compliance with ARARs applicable to discharge of treated water to surface water.

SW Alternative 9 by itself would not comply with chemical-specific ARARs (specifically, MTCA Method B) for discharge of groundwater containing COCs to surface water, and would not sufficiently reduce risks to human health.

9.2.3 Long-Term Effectiveness and Permanence

The no-action alternative for surface water is not expected to be effective. Groundwater containing COCs would continue to daylight at the base of the Palermo Bluff, creating current and future risk to human health and the environment.

SW Alternatives 2 through 8 address surface water that results from the seepage of near-surface groundwater at the base of the Palermo Bluff near the Rainier Avenue residences. None of these

alternatives are able to address residual COCs in groundwater upgradient of the Rainier Avenue residences. Collection and treatment of surface water using any of SW Alternatives 2 through 8 would have to be maintained until COCs in upgradient groundwater were removed either using one of the groundwater alternatives evaluated in Section 9.1, or through natural degradation.

SW Alternative 9 by itself would reduce vapors in residential crawlspaces (although not sufficiently to reduce the risk to acceptable levels) but would not address COCs in seeping groundwater.

Treatment residuals are most numerous for SW Alternative 7 (phytoremediation), and include transpired air, waste tree tissues, treated water, and sparge air offgas. Treatment residuals for SW Alternatives 2, 3, 4, and 8 include air offgas and treated water potentially containing COCs. Treatment residuals for SW Alternative 5 (carbon adsorption) include treated water and spent carbon. Treatment residuals for SW Alternative 6 (photo-oxidation) consist primarily of treated water. Treatment residuals for SW Alternative 9 consist of ventilated air containing COCs.

9.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

No reduction of toxicity, mobility, or volume would occur as a result of the no-action alternative.

The volume of COCs in water would be reduced by the removal of COCs from collected water by the treatment process used by each alternative.

SW Alternative 7 (phytoremediation) would also reduce the toxicity of COCs by metabolizing some of the PCE and TCE to other compounds. SW Alternative 9 (crawlspacse ventilation) would reduce the volume of COCs by ventilating the Rainier Avenue residential crawlspaces.

9.2.5 Short-Term Effectiveness

Installation of the french drain required for SW Alternatives 2 through 8 would be performed in an area that is currently densely vegetated, with poor equipment access, near residences, and either beneath shallow ponded surface water containing COCs or with saturated soil conditions. These characteristics would require careful preparation; however, the public and workers could be protected using standard construction and hazardous site safety protocols. Some nuisance noise would result from several weeks of construction activities. Construction would require 2 to 4 weeks.

Construction of the treatment components of SW Alternatives 2, 3, 4, 5, and 6 would be performed in the same general location as, and concurrently with, the french drain. No additional short-term effectiveness issues would result. For SW Alternative 7 (phytoremediation),

construction of the tree plantations would require substantially more land area to be purchased, cleared of existing vegetation and graded. The requirement to maintain the tree plantation free of undergrowth for the first two years could create erosion problems. For SW Alternative 8 (lagoon aeration), additional construction noise would be created at the east end of M Street. Some golf course land would be converted to lagoon. Nuisance noise from ongoing surface aerator operation could require noise prevention measures.

For SW Alternative 9 (crawlspce ventilation), some short-duration disruption would occur for residents during installation of the ventilation systems. A long-term small increase in electricity usage would also result, as well as some low nuisance noise. However, ventilation fans have been specifically designed to minimize noise.

Lowering the water table using the french drain would reduce risks from inhalation of PCE and TCE vapors emitted by surface water within 1 to 2 weeks of completion of construction.

Based on models developed using substantial empirical data for PCE and TCE treatment, vendors can size air strippers and carbon adsorption vessels (SW Alternatives 4 and 5, respectively) for excellent effectiveness. Either of these technologies would be expected to effectively remediate surface water to the RGs for PCE and TCE. Photo-oxidation is also likely to be highly effective, and could be sized by the vendor based on past experience and a bench-scale treatability test (SW Alternative 6). Parameters that could adversely affect these three technologies include variations in the estimated water influent flow rate and contaminant concentrations, and water influent characteristics that promote fouling.

In-drain air sparging and lift station sparging (SW Alternatives 2 and 3, respectively) are both likely to be effective in remediating surface water to the RGs for PCE and TCE. Neither a body of historical operational data nor a widely used model is available for these technologies (as compared to air stripping, carbon adsorption, or photo-oxidation). Therefore, the effectiveness of either method of air sparging cannot be as reliably predicted. Increased confidence in the effectiveness of these alternatives could be achieved by field testing various rental blowers attached to the full-scale sparge piping, to confirm the required air flow rate for effective remediation.

Lagoon aeration (SW Alternative 8) is likely to be effective in remediating surface water to the RGs for PCE and TCE. As for the two air sparging technologies, a direct, quantitative evaluation method for this alternative is not available. Methods for evaluating the technology's effectiveness for sewage treatment must be adapted to evaluate effectiveness for stripping PCE and TCE. The effectiveness of lagoon aeration at this site is dependent on locating the lagoon at the M Street outfall to take advantage of mixing and turbulence in the stormdrain system, and providing a lengthy residence time in the lagoon.

Phytoremediation (SW Alternative 7) is likely to be effective in remediating surface water to the RGs for PCE and TCE after maturation of the trees in approximately 2 to 5 years, and during the growing season (April through November). Without a french drain to supplement the tree uptake in the area of ponding, surface water is likely to remain west of the Rainier Avenue residences. Without a supplementary remediation alternative, such as lift station sparging, phytoremediation will not be effective during the dormant season.

Crawlspace ventilation (SW Alternative 9) would be effective at reducing inhalation hazards but would not directly address water containing COCs.

9.2.6 Implementability

Crawlspace ventilation (SW Alternative 9) would require the least complex construction effort. Confined space entry would be required, and the workspace would have to be dewatered prior to construction. The confined nature of the workspace would make piping and vapor barrier installation slow and difficult. Even considering these difficulties, however, less construction effort would be required to install ventilation systems in eight homes than required for alternatives that involve earth moving. The ventilation fans to be installed are warrantied for 5 years and require little maintenance beyond periodic visual inspections and electricity usage.

Lagoon aeration (SW Alternative 8) requires the second least complex construction effort. The required basin will require substantial earth moving; however, the basin is small compared to similar structures and the construction techniques are straightforward. Placement of the aerators requires only setting two posts, tethering the aerators to the posts, and providing electrical power to the aerators. Location of the lagoon at the M Street outfall makes use of the existing power drop for the current sanitary sewer lift station. No plumbing is required for this alternative.

Of the alternatives requiring construction at the drain site, carbon adsorption (SW Alternative 5) would require the least construction effort. This alternative requires no modification of the lift station used for operation of the french drain and requires a minimum of aboveground construction and treatment equipment. Air stripping (SW Alternative 4) requires slightly more construction effort than carbon adsorption, because an insulated housing would be required for noise reduction, and more equipment is required. Photo-oxidation (SW Alternative 6) requires more construction effort than either carbon adsorption or air stripping, because of the larger concrete pad size required to site the equipment. The skid-mounted photo-oxidation module is self-contained and would require minimal piping of individual treatment components. A crane would be required to place the module.

Lift station sparging (SW Alternative 3) would require less aboveground construction effort than carbon adsorption, air stripping, or photo-oxidation. The concrete pad would require no

secondary containment and could be smaller in size, and noise reduction could be achieved with a portable cover. Lift station sparging would require installation of a second lift station vault, however. The second vault would have to be modified with a baffle and sparge piping. These subsurface activities make the overall construction effort slightly greater for this alternative than for the aboveground treatment alternatives.

In-drain sparging (SW Alternative 2) would require more construction effort than lift station sparging. Only one lift station vault would be required, and the concrete pad would be identical to that for lift station sparging. Construction of the header pipe, valving, and in-drain sparge piping, however, add substantially to the construction effort requirements. Institutional controls would be required along the entire length of the french drain.

Phytoremediation (SW Alternative 7) would require more construction effort than all other feasible alternatives. Even if construction of the lift station sparging supplemental treatment system is not included, acquiring easements for planting, performing planting, and constructing water conveyance and distribution systems would require substantially more effort than limiting construction to the immediate area of ponding.

Operation and maintenance requirements for all of the alternatives are similar. A monthly O&M frequency is likely to be required for equipment used at the site. Lagoon aeration would require the least O&M effort. The aerators are available with maintenance-free motors, and no piping or filters would exist to require cleaning. Occasional cleaning of the aerator jets and the basin might be required. Lift station sparging would require the next least O&M effort. The blower used for sparging would require monthly lubrication and belt tension inspection, and periodic oil changes. In-drain sparging would require a similar level of effort, but would also require balancing of sparge air flow at valve locations along the length of the drain.

Air stripping would require cleaning and inspection of the air stripper tray. Carbon adsorption would require influent filter element changes. Carbon adsorption would also require periodic backflushing and yearly carbon regeneration. Photo-oxidation would require maintenance visits as often as twice per month, but has no filter elements that require frequent change-outs. Photo-oxidizer maintenance could be provided by the vendor.

Phytoremediation would initially require the most O&M effort, if combined with lift station sparging. Tree monitoring and maintenance would be in addition to lift station sparging O&M. However, this alternative may result in the lowest long-term O&M. If the trees perform well, they may require relatively little O&M and may eliminate the need for lift station sparging.

9.2.7 Cost

Of the active surface water alternatives that meet all RAOs, lagoon aeration (SW Alternative 8) appears to be the lowest capital cost and total cost alternative. The in-drain sparging, lift station sparging, air stripping, and carbon adsorption alternatives are estimated to be \$35,000 to \$95,000 more costly than lagoon aeration. The higher estimated costs for these alternatives result from various factors, including requirements for pilot testing, more complex drain construction, and higher-maintenance equipment. Crawlspace ventilation is the lowest-cost alternative, but does not meet all of the RAOs.

Photo-oxidation is one of the two highest-cost alternatives, because of the high capital costs for the photo-oxidation unit, and the frequent O&M visits required for proper operation. Because phytoremediation would require a supplementary technology, such as lift station sparging, the cost to implement this alternative is higher than all other alternatives. Capital costs in particular are higher for phytoremediation because of the estimated high cost of procuring land for planting.

Costs for each of the alternatives are summarized in Table 9-1.

9.2.8 State Acceptance

Ecology has been involved with the development and review of the RI, FS, proposed plan, and ROD. Ecology's participation has resulted in substantive changes to these documents. Ecology concurs with the selection of Alternative 8 for surface water at the Palermo Wellfield Superfund Site.

9.2.9 Community Acceptance

A responsiveness summary of the comments is provided in Appendix A of this document.

The issues regarding surface water that were discussed during the public meeting and in subsequent written comments included:

- How will the french drain protect residents of the Palermo neighborhood that don't live along Rainier Avenue? Are other residents that currently experience crawlspace flooding at risk from site contaminants? How far east of Rainier Avenue will the remedial effects of the french drain extend?
- How will wildlife and existing plant life be protected during construction of the french drain?

- How much noise will be generated by the lift station at the north end of the french drain?
- Will the french drain cross the private property of the residents of Rainier Avenue?
- What are the current risks from breathing COC vapors? Should local residents change any habits to protect themselves from current risks? What is the risk from being exposed for the time period before the remedy is implemented?
- Will there be any physical hazards to local residents and wildlife from the french drain or lagoon?

None of the issues identified resulted in changes to the concepts of the preferred alternative for surface water. In general, public comments were in support of the selected remedy. However, public comments did result in EPA modifying the remedy to include characterization of residences east of Rainier Avenue for possible inclusion in the remedy. In addition, the community's concerns were incorporated into the design criteria for the detailed remedial design.

9.3 SOIL

9.3.1 Overall Protection of Human Health and the Environment

The no-action alternative would not meet the RAO for soil. Chlorinated VOCs would remain in soil at Southgate and would continue to partition into groundwater. Soil Alternatives 2 and 3 would have very similar protective effects, because the majority of available contaminant would be removed during the first year of operation.

9.3.2 Compliance With ARARs

Both action alternatives would satisfy all chemical-, action-, and location-specific ARARs for soil. Satisfaction of chemical-specific ARARs throughout the volume of soil containing PCE and TCE would require sufficient time for natural degradation of chlorinated VOCs not directly addressed by active remediation.

9.3.3 Long-Term Effectiveness and Permanence

Both action alternatives would primarily reduce PCE concentrations at Southgate. Soil Alternative 3 would have a slightly greater effectiveness because of increased contaminant removal over time.

9.3.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Both alternatives would reduce the volume and mobility of the chlorinated VOCs at Southgate by removing PCE from soil. The majority of the volume removal is expected to occur in the first year under Soil Alternative 2. Based on recent data from the operating SVE system, operation of the SVE system from the second year following installation through the fifth year might be expected to remove another 10 to 100 pounds of PCE.

9.3.5 Short-Term Effectiveness

Short-term effectiveness issues are minimal for both alternatives. System installation is complete, and the system is operational. Operation-and-maintenance and health-and-safety documentation have addressed impacts to workers and the community.

9.3.6 Implementability

SVE at Southgate is already implemented.

9.3.7 Cost

Operating the Southgate SVE system for one year is expected to incur approximately one-third the cost of operating the system for five years. Costs are summarized in Table 9-1.

9.3.8 State Acceptance

Ecology has been involved with the development and review of the RI, FS, proposed plan, and ROD. Ecology's participation has resulted in substantive changes to these documents. Ecology concurs with the selection of Soil Alternative 3 at the Palermo Wellfield Superfund Site.

9.3.9 Community Acceptance

A responsiveness summary of the comments is provided in Appendix A of this document.

The issues regarding soil that were discussed during the public meeting and in subsequent written comments included:

- Wasn't Southgate Dry Cleaner a permitted facility at the time it was causing the contamination?
- How does EPA determine and justify financial responsibility for contamination?

Neither of the issues identified resulted in changes to the preferred alternative for soil.

Table 9-1
Summary of Costs for Remedial Alternatives
Palermo Wellfield Superfund Site

Alternative	Total Capital Cost (\$)	5-year O&M Cost (Present Worth at 5%, in \$)	Total Present-Worth Cost (5-year basis, in \$)
Groundwater:			
2: Limited Action	3,980,000	880,000	4,860,000
3a: Upland Action Area Remediation by HRC™ - Southgate, Brewery City Pizza, and Chevron	4,680,000	3,610,000	8,290,000
3b: Upland Action Area Remediation by HRC™ - Southgate and Brewery City Pizza	4,480,000	2,710,000	7,190,000
3c: Upland Action Area Remediation by HRC™ - Southgate	4,280,000	1,820,000	6,100,000
4: Plume Interception by Air Sparging	4,210,000	1,770,000	5,980,000
5a: Upland Action Area Remediation by Air Sparging - Southgate	4,140,000	1,650,000	5,790,000
5b: Upland Action Area Remediation by Air Sparging - Brewery City Pizza	4,180,000	1,700,000	5,880,000
5c: Upland Action Area Remediation by Air Sparging - Chevron	4,180,000	1,640,000	5,820,000
6a: Upland Action Area Remediation by Pump and Treat - Southgate	4,150,000	1,200,000	5,350,000
6b: Upland Action Area Remediation by Pump and Treat - Brewery City Pizza	4,140,000	1,190,000	5,330,000
6c: Upland Action Area Remediation by Pump and Treat - Chevron	4,140,000	1,200,000	5,340,000
Surface Water/Indoor Air:			
2: In-drain Sparging Aeration	213,000	306,000	519,000
3: Lift Station Sparging Aeration	208,000	300,000	508,000
4: Air Stripping	211,000	294,000	505,000
5: Carbon Adsorption	200,000	365,000	565,000
6: Photo-Oxidation	241,000	475,000	716,000
7: Phytoremediation with Lift Station Sparging	736,000	472,000	1,208,000
8: Lagoon Aeration	186,000	283,000	469,000
9: Crawlspace Ventilation	135,000	300	135,000
Soil:			
2: Southgate Remediation by SVE for one year	400,000	100,000 ^a	500,000

Table 9-1 (Continued)
Summary of Costs for Remedial Alternatives
Palermo Wellfield Superfund Site

Alternative	Total Capital Cost (\$)	5-year O&M Cost (Present Worth at 5%, in \$)	Total Present- Worth Cost (5-year basis, in \$)
3: Southgate Remediation by SVE for five years	400,000	433,000	833,000

Notes:

*O&M costs for soil Alternative 2 are only for one year of O&M. Estimated costs have an accuracy of +50 percent to -30 percent.

Table 9-2
Comparison of Groundwater Alternatives

GW Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
1: No Action	Would not reduce current risks.	Would not comply with chemical-specific ARARs.	Would be effective only through natural degradation, which appears to act slowly at the site.	No treatment.	No short-term risks or impacts.	No implementability issues.	No cost.
2: Limited Action	Would prevent access and provide remediation at point of exposure. Would eventually remediate entire plume.	Would comply with ARARs. Uses air stripping to meet ARARs at point of exposure.	Would take the longest to reduce residuals of all action alternatives, but would eventually remediate the entire plume.	Reductions would be result of well field air stripping and natural degradation. PCE and TCE from upland action areas would eventually be captured.	Air strippers are being constructed in a fenced compound somewhat isolated from community. No other components with potential impacts.	Air strippers at Palermo Wellfield are currently being implemented. Deed restrictions and well drilling restrictions may require substantial negotiation.	Total Capital: \$3,980,000 5-yr O&M: \$880,000 TOTAL: \$4,860,000
3: HRC™ in Upland Action Areas	Would prevent access, provide remediation point of compliance, and provide residual remediation at upland action areas. Would protect downgradient receptors by removing COCs upgradient.	Would enhance natural degradation, thereby reducing residuals in less time than GW Alternative 2. Would comply with ARARs at point of compliance as GW Alternative 2.	Technology has not been proven at full scale, and may not be effective at the site. If HRC is not effective, GW Alternative 3 defaults to GW Alternative 2. HRC would require yearly emplacement.	Volume would be reduced by enhanced degradation of chlorinated VOCs. Toxicity would temporarily increase, but eventually be decreased.	Drive point installation would have similar impacts in upland action areas as drive point sampling during the RI. Some short-term inconvenience to businesses.	Drive point technology has been shown effective during the RI. Emplacement of HRC™ performed as backfill of drive points. Readily implemented.	Total Capital: \$4,680,000 5-yr O&M: \$3,610,000 TOTAL: \$8,290,000

Table 9-2 (Continued)
Comparison of Groundwater Alternatives

GW Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
4: Air Sparging Interception	Would prevent access, provide remediation at point of compliance, and protect downgradient receptors by intercepting migrating plume.	Would reduce residuals to ARARs via natural degradation throughout most of the aquifer. Would comply with ARARs at point of compliance.	Air sparging is a proven technology. Would require long-term maintenance of equipment.	Would reduce mobility by intercepting migrating plume. Would reduce volume by removing COCs as groundwater migrates through sparge curtain.	Impacts to community minimal. Protection through standard techniques. Vapor extraction may not be effective because of shallow groundwater.	Readily implemented. Wells could be installed using standard equipment. Implementation would be facilitated by first installing surface water structures.	Total Capital: \$4,210,000 5-yr O&M: \$1,770,000 TOTAL: \$5,980,000
5: Air Sparging in Upland Action Areas	Similar to GW Alternative 3.	Would remove COCs in upland action areas, thereby reaching compliance with chemical-specific ARARs throughout aquifer in a shorter time than GW Alternative 2. Would comply at point of compliance.	Would result in sitewide reduction of COC residuals through flow of remediated water from upland action areas. Would require long-term maintenance of equipment.	Would reduce volume by stripping COCs from groundwater in upland action areas. Would not substantially reduce mobility. Improper design or monitoring could exacerbate chlorinated VOC mobility.	Construction would have similar short-term impacts to the community as investigations performed during the RI. Some researchers question effectiveness.	Could be implemented using standard well drilling and construction techniques. Substantial piping and equipment installation required, including piping under Capitol Boulevard.	Southgate total: \$5,790,000 Brewery City Pizza total: \$5,880,000 Chevron total: \$5,820,000

Table 9-2 (Continued)
Comparison of Groundwater Alternatives

GW Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
6: Pump and Treat in Upland Action Areas	Would prevent access, provide remediation at point of compliance, and provide remediation at upland action areas. Would protect downgradient receptors by capturing and removing COCs upgradient.	Same as GW Alternative 5.	Same as GW Alternative 5.	Would reduce volume by removing COCs from groundwater in upland action areas. Would reduce mobility by capturing groundwater migrating from upland action areas.	Construction would have similar short-term impacts to the community as investigations performed during the RI. Aboveground air stripping effective, pump-and-treat effective.	Similar to GW Alternative 5. More equipment required than for GW Alternative 5, resulting in more potential faults and O&M costs. Would generate estimated 150 gpm for disposal.	Southgate total: \$5,350,000 Brewery City Pizza total: \$5,330,000 Chevron total: \$5,340,000

Notes:

Some remedies shown above may be operated for larger than the 5-year timeframe upon which the present worth value is based. For such remedies, O&M costs beyond 5 years are expected to be similar to those for the first 5 years.

The state and community concur with the selection of Alternative 2 as the remedy for groundwater.

ARAR - applicable or relevant and appropriate requirement

COC - chemical of concern

GW - groundwater

HRC™ - proprietary polylactate ester

O&M - operation and maintenance

PCE - tetrachloroethene

RI - remedial investigation

TCE - trichloroethene

VOC - volatile organic compound

Table 9-3
Comparison of Surface Water Alternatives

SW/Indoor Air Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
1: No action	Would not reduce current risks.	Would not comply with chemical-specific ARARs.	Would not be effective at reducing COC concentrations.	Would not reduce COC toxicity, mobility, or volume.	No short-term risks or impacts. Not effective.	Readily implemented.	No cost.
2: In-drain sparging	Would collect and treat water, preventing exposure at the Rainier Avenue residences and removing COCs.	Would comply with all ARARs at point of compliance.	Does not address residual COCs in groundwater upgradient, so would require maintenance for an indefinite period. Residuals include treated water and sparge air offgas.	Would reduce mobility by capturing water containing COCs. Would reduce volume by removing COCs from captured groundwater.	Could be implemented with minimal impacts. Likely to remediate COCs to RGs, but would require field pilot test to verify effectiveness.	Small concrete pad. Single lift station vault. Piping, valving, fencing required along entire length of drain. Piping installation inside drain difficult. Low O&M.	\$213,000 total capital costs. \$519,000 total present-worth costs for 5-year life.
3: Lift station sparging	Same as SW Alternative 2.	Same as SW Alternative 2.	Same as SW Alternative 2.	Same as SW Alternative 2.	Same as SW Alternative 2.	Small concrete pad. Two lift station vaults. Modification of one vault for sparge piping. Low O&M.	\$208,000 total capital costs. \$508,000 total present-worth costs for 5-year life.
4: Air stripping	Same as SW Alternative 2.	Same as SW Alternative 2.	Same as SW Alternative 2.	Same as SW Alternative 2.	Could be implemented with minimal impacts. Equipment size based on well-established models. Would remediate COCs to RGs.	Medium-sized concrete pad. Single lift station vault. Plumbing of individual treatment equipment components. Moderate O&M.	\$211,000 total capital costs. \$505,000 total present-worth costs for 5-year life.
5: Carbon adsorption	Same as SW Alternative 2.	Same as SW Alternative 2.	Similar to SW Alternative 2. Difference is that residuals are treated water and spent carbon.	Same as SW Alternative 2.	Same as SW Alternative 4.	Medium-sized concrete pad. Single lift station vault. Plumbing of individual treatment equipment components. Moderate O&M.	\$200,000 total capital costs. \$565,000 total present-worth costs for 5-year life.

Table 9-3 (Continued)
Comparison of Surface Water Alternatives

SW/Indoor Air Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
6: Photo-oxidation	Same as SW Alternative 2.	Same as SW Alternative 2.	Similar to SW Alternative 2. Difference is that only residual is treated water.	Same as SW Alternative 2.	Minimal impacts. Guaranteed by vendor to remediate PCE to target effluent concentration, but requires bench-scale treatability test.	Large concrete pad. Self-contained, crane-placed equipment skid. Single lift-station vault. High O&M.	\$241,000 total capital costs. \$716,000 total present-worth costs for 5-year life. Treatability testing not included.
7: Phyto-remediation with lift station sparging	Same as SW Alternative 2.	Same as SW Alternative 2.	Similar to SW Alternative 2. Difference is residuals, which include treated water, sparge air offgas, transpiration air, and tree tissues.	Would reduce mobility and volume in the same way as SW Alternative 2. Would also reduce toxicity by metabolizing some COCs.	More substantial impacts because several acres must be cleared and planted. Trees must have sparging supplement to be effective year-round.	Lift station construction plus planting of two 2-acre areas. Off-site planting would require fencing and irrigation system to distribute treatment water. Highest O&M. Lift station sparging O&M required plus tree maintenance and monitoring.	\$736,000 total capital costs. \$1,208,000 total present-worth costs for 5-year life.
8: Lagoon aeration	Similar to SW Alternative 2. May be slightly less protective than other alternatives because of conveying contaminated water to remote treatment location.	Same as SW Alternative 2.	Similar to SW Alternative 2. Difference is residuals, which include lagoon air offgas and treated water.	Same as SW Alternative 2.	Greater impacts than SW Alternatives 2-6, but less impact than SW Alternative 7. Likely to remediate COCs to RGs, but effectiveness cannot be directly calculated.	No plumbing required. Can use existing electrical drop. Requires excavation of unlined basin 85 ft by 43 ft by 6 ft deep. Lowest O&M.	\$186,000 total capital costs. \$469,000 total present-worth costs for 5-year life.
9: Crawlspace ventilation	Would achieve protection by removing vapors from crawlspaces rather than removing source water.	Would not satisfy chemical-specific ARARs for surface water.	Would reduce inhalation exposure. Residuals include ventilated air.	Would reduce COC volume by removing vapors from crawlspaces.	Disruption to homeowners during installation. May not be as effective without lowering water table.	Difficult to construct without lowering water table.	\$135,000 total capital costs. No substantial O&M costs.

Table 9-3 (Continued)
Comparison of Surface Water Alternatives

SW/Indoor Air Alternative	Overall Protection	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short-Term Effectiveness	Implementability	Cost (\$)
8 & 9: combined Lagoon aeration (with french drain) and crawlspace ventilation	Protects by both lowering water table and removing crawlspace vapors.	Same as SW Alternative 2.	Similar to SW Alternative 2. Difference is residuals, which include lagoon air offgas, vented crawlspace vapors, and treated water.	Same as SW Alternative 2.	Greatest disruption to homeowners because of work both near and under homes.	Installing french drain first simplifies installation of vent systems.	\$321,000 total capital costs. \$604,000 total present-worth costs for 5-year life.

Notes:

Some remedies shown above may be operated for larger than the 5-year timeframe upon which the present worth value is based. For such remedies, O&M costs beyond 5 years are expected to be similar to those for the first 5 years.

The state and community concur with the selection of Alternative 8 as the remedy for surface water.

ARAR - applicable or relevant and appropriate requirement

COC - chemical of concern

O&M - operation and maintenance

PCE - tetrachloroethene

RG - remedial goal

SW - surface water

10.0 THE SELECTED REMEDY

10.1 SUMMARY OF THE RATIONALE FOR THE SELECTED REMEDY

Based on consideration of CERCLA requirements and analysis of alternatives using the nine evaluation criteria, including public comment, EPA has determined that the following alternatives constitute the most appropriate remedy for the Palermo Wellfield Superfund Site:

- Alternative 2 for groundwater consists of treating groundwater at the Palermo Wellfield, monitoring groundwater, and preventing the drilling of wells within the plume of contamination. The primary factors in selecting this alternative include providing comparable protection to human health and the environment with less disruption to the local community and at a lower cost than Alternatives 3, 4, 5, or 6.
- Alternative 8 for surface water/indoor air consists of installation of a french drain west of the Rainier Avenue residences and treatment of the water collected by the french drain using an aerated lagoon at the Tumwater Municipal Golf Course. The primary factors in favoring this alternative include providing comparable protection with less disruption to the residents of the Palermo Valley and at a lower cost than Alternatives 2 through 7 and Alternative 10. Alternative 9 was not chosen, as it would not on its own adequately lower the health risk to the residents along the west side of Rainier Avenue. However, Alternative 9 may be used in conjunction with Alternative 8 to address the houses along the west side of Rainier Avenue or on its own to address potential problems in houses to the east of Rainier Avenue.
- Alternative 3 for soil at the Southgate Dry Cleaners consisting of soil vapor extraction and treatment of the vapors with activated carbon. The primary factors in selecting this alternative for soil include the fact that the SVE system has already been installed and is still removing appreciable amounts of PCE that would otherwise add to the groundwater problem. Modeling indicates that the soils still contain levels of PCE above the cleanup level. Soil samples will be collected to confirm that soil RGs have been attained. If these confirmatory soil samples indicate that the soil RGs have not been attained, deed restrictions will be put in place on the property of Southgate Dry Cleaners to reduce the future transfer of contaminants from soil to groundwater.

10.2 DESCRIPTION OF THE SELECTED REMEDY

- The air stripping system constructed by EPA will be operated and maintained by the City to treat contaminated groundwater at the Palermo Wellfield for distribution into the municipal drinking water system. Water will be treated to levels no greater than MCLs for TCE and PCE.
- A french drain will be installed west of the residences located along the west side of Rainier Avenue. The french drain will be designed to lower the water table to a depth of 18 inches below the bottom of the crawlspaces under the residences along the west side of Rainier Avenue. Lowering the water table will reduce modeled indoor air concentrations of TCE and PCE to below the MTCA Method B air cleanup values of $1.46 \mu\text{g}/\text{m}^3$ for TCE and $4.38 \mu\text{g}/\text{m}^3$ for PCE. The drain will collect shallow groundwater and route it to the Tumwater Municipal Golf Course where it will be treated by aeration in a lagoon. Treated water will drain through the existing stormwater ditch, eventually discharging to the Deschutes River. The aerated lagoon will be designed to treat water such that the water in the stormwater ditch meets water quality standards for COCs prior to discharge into the Deschutes River. The water quality standards are based on the National Toxics Rule which is protective of the human consumption of water and aquatic organisms. The standards are 0.8 ug/L and 2.7 ug/L for PCE and TCE, respectively.
- An evaluation of the standing water in the Palermo community will be made. If standing water is found in the crawlspace under any home east of Rainier Avenue, it will be sampled and analyzed for PCE and TCE. If PCE or TCE is found in crawlspace water, the risk to residents of those houses will be assessed by the same methodology used in the RI human health risk assessment. If unacceptable risks are found, remedial action will be taken by either lowering the water table beneath the house or by venting the crawlspace. The choice between these two remedies will be made based upon cost effectiveness.
- The SVE system at the Southgate Dry Cleaners will continue to operate until the soil cleanup goal for PCE is met. The cleanup goal is 0.0858 mg/kg and is based on the MTCA Method B soil cleanup level for the protection of groundwater. Attainment of the soil RG goal will be evaluated based on PCE concentrations in vapor discharged from the remediation system. The change in the PCE concentrations in vapor from the initial concentration to the most recent concentration will be used to establish the present PCE concentration in soil based

on the initial PCE concentration in soil. When compliance is determined, the SVE system will be shut down and removed from the site, and the extraction wells will be abandoned in accordance with ARARs. Soil samples will be collected to confirm that soil RGs have been attained. If these confirmatory soil samples indicate that soil RGs have not been attained at the time of system shut-down, deed restrictions will be put in place on the Southgate Dry Cleaner property to reduce the transfer of contaminants from soil to groundwater.

- A long-term groundwater monitoring program will be developed using existing wells. Wells that are not needed for the long-term monitoring program will be abandoned in accordance with ARARs. Groundwater monitoring will track the contaminant plume until levels of TCE and PCE are consistently less than their MCLs throughout the aquifer at the site. Groundwater samples will be analyzed for PCE, TCE, and its breakdown products.
- A sampling program will be developed and implemented to determine the effectiveness of the french drain system. This program will focus on monitoring depth to groundwater to demonstrate that a minimum 18-inch depth of dewatering is maintained.
- A monitoring system will be developed and implemented for the discharge from the aerated lagoon. The monitoring will confirm that the water in the lagoon meets water quality standards prior to discharge to the Deschutes River.
- Notification will be provided to property owners, well drillers, and local officials regarding the specific location of the groundwater contaminant plume. The notification will advise that the groundwater in this area is not safe for domestic use without treatment. In the FS report, the mechanism for prevention of the use of contaminated groundwater was anticipated to be a City ordinance. Because this mechanism would be difficult to implement, and because there is very little incentive for individuals to drill new domestic wells in this fully developed area, public education was selected as a more appropriate mechanism.

10.3 SUMMARY OF THE ESTIMATED REMEDY COSTS

Table 10-1
Capital Cost Estimate Summary for the Selected Remedy

Description	Quantity	Unit	Unit Cost	Cost
1. Palermo Wellfield air stripping construction costs	1	LS	\$3,800,000	\$3,800,000 ^a
2. Well drilling notification	1	LS	\$3,000	\$3,000
3. Groundwater monitoring plan preparation	1	LS	\$15,000	\$15,000
4. SVE construction	1	LS	\$400,000	\$400,000 ^a
5. French drain construction	1	LS	\$94,000	\$94,000
6. Aerated lagoon construction	1	LS	\$92,000	\$92,000
7. Palermo neighborhood standing water evaluation	1	LS	\$25,000	\$25,000
8. Lagoon monitoring plan	1	LS	\$10,000	\$10,000
9. French drain monitoring plan	1	LS	\$10,000	\$10,000
Total Estimated Construction Cost				\$4,450,000

^aConstruction of the air stripping system and SVE system has already occurred

Notes:

New construction costs include 20 percent for contingencies.

Cost estimates are accurate to between +50 percent and -30 percent.

Table 10-2
O & M Cost Estimate Summary

Description	Quantity	Unit	Unit Cost
1. Palermo Wellfield air stripping (includes monitoring costs)	5	Years	\$95,000
2. Groundwater monitoring program	5	Years	\$105,000
3. SVE operation (includes monitoring costs)	5	Years	\$100,000
4. Operation of french drain and aerated lagoon (includes monitoring costs)	5	Years	\$65,000
Total Estimated Yearly O&M Cost			\$365,000

Notes:

Cost estimate includes 20 percent for contingencies.

Cost estimates are accurate to between +50 percent and -30 percent.

Table 10-3
Present Worth Analysis Summary

Description	Cost
1. Total Capital Cost	\$4,450,000 ^a
2. Present Worth O&M for Air Strippers (includes monitoring costs)	\$ 400,000
3. Present Worth O&M for SVE System (includes monitoring costs)	\$ 433,000
4. Present Worth O&M for French Drain/Aerated Lagoon (includes monitoring costs)	\$ 283,000
5. Present Worth O&M for Groundwater Monitoring	\$ 482,000
Total Present Worth Costs (5 years)	\$6,050,000*

^aConstruction costs of \$4,200,000 have already been expended.

Notes:

Present worth O&M is based on 5 years with 5 percent discount factor.

Cost estimates are accurate to between +50 percent and -30 percent.

10.4 EXPECTED OUTCOMES OF THE SELECTED REMEDY

This section presents the expected outcomes of the selected remedy in terms of resulting land and groundwater uses and risk reduction achieved as a result of the response action.

- Soil under the Southgate Dry Cleaners is expected to meet cleanup levels within 6 months to a year; after which time the SVE system will be dismantled. After this time, no land use restrictions at Southgate Dry Cleaners are anticipated to be needed due to the Superfund site unless confirmatory soil samples indicate that soil RGs have not been attained. Minor land use restrictions will be required in the Palermo valley because of the french drain and aerated lagoon. After construction, the french drain will be underground and not apparent from the ground surface; however, no excavation above the french drain line would be allowed. Also the presence of the aerated lagoon will prevent any other use of this small piece of land.
- The air stripping treatment system at the Palermo Wellfield will need to be operated until groundwater levels of COCs consistently meet drinking water standards in all wells at the wellfield. Modeling indicates that groundwater throughout the plume will meet drinking water standards in a timeframe of 5 to 30 years. However, it is expected that the City will operate the air stripping system after this time since the air stripping also controls the pH of the water supply and the City is required to control pH by the Washington State Department of Health.
- The french drain and aerated lagoon will need to be operated until shallow groundwater meets the RGs for surface water. This criterion applies to shallow groundwater with the potential to create ponded surface water in the absence of the french drain. Modeling indicates that it will take from 5 to 30 years for this to occur. Preliminary estimates indicate that within a few weeks of starting up the french drain system, potential levels of TCE and PCE in indoor air emanating from crawlspaces will be reduced to acceptable levels. Following the remedial action, risk from inhalation of indoor air containing COCs will be reduced to 1×10^{-6} or below. The land used for the lagoon will not be used for any other purpose during the life of the project. No other land use restrictions are anticipated because of the Superfund site.

11.0 STATUTORY DETERMINATIONS

Under CERCLA, selected remedies must protect human health and the environment, comply with ARARs, be cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that use treatments that significantly and permanently reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy for the Palermo Wellfield Superfund Site meets these statutory requirements.

11.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy would protect human health and the environment by:

- Preventing the ingestion and use of groundwater containing COCs
- Removing and treating recoverable COC vapors in the area of Southgate Mall, to reduce the COCs in soil available for partitioning to groundwater
- Treating extracted water at the Palermo Wellfield to remove COCs from the municipal water supply
- Lowering the groundwater elevation in the area of the Rainier Avenue residences to prevent the ponding of water and subsequent volatilization of COCs in the crawlspaces
- Monitoring changes in COC concentrations throughout the Palermo Wellfield Superfund Site by sampling of existing groundwater wells to assess remedy effectiveness and monitor the production of COC breakdown products.

These elements of the remedy will prevent access to COCs where they are present; collect and treat contaminated groundwater at the current points of exposure; collect and treat COCs in the area of highest concentration (in soil) upgradient of the points of exposure. COCs will be removed from the soil below Southgate Dry Cleaners until levels meet ARARs. COCs will be eliminated from the drinking water supplied from the Palermo Wellfield wells. Groundwater seepage (surface water) containing COCs at the base of the Palermo bluff will be intercepted underground before it daylight, and maintained at an elevation below the bottom of the nearby

residential crawlspaces; thereby lowering potential levels of COCs in indoor air to meet ARARs levels. Monitoring will help assure the future protectiveness of the remedy by gauging the effectiveness of various elements of the remedy and tracking changes to COC concentration and location. Groundwater monitoring will be conducted until COC levels are below ARARs levels throughout the site.

Implementation of the selected remedy is not expected to pose unacceptable short-term risks or significant cross-media impacts.

11.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The selected remedy for the Palermo Wellfield Superfund Site will comply with federal and state ARARs that have been identified. No waiver of any ARAR is being sought or invoked for any component of the selected remedies. Where a state ARAR is equivalent or more stringent than a corresponding federal ARAR, only the state ARAR is identified. The chemical-, action-, and location-specific ARARs identified for the site follow.

- **Washington State Safe Drinking Water Act and implementing regulations (WAC 246-290).** The Washington State Department of Health implements the drinking water program in Washington State. Primary MCLs are the maximum concentrations of chemicals permitted in public drinking water systems and are identified in WAC 246-290-310. Primary MCLs are relevant and appropriate for the groundwater at the Palermo Wellfield because groundwater within the site is withdrawn to provide residential drinking water; they are applicable at the taps of the homes in the City. The primary MCLs for PCE and TCE are the same: 5.0 micrograms per liter ($\mu\text{g/L}$). Operation of the air strippers installed at the Palermo Wellfield will ensure that these MCLs are met..
- **Washington State Model Toxics Control Act (MTCA) and implementing regulations (WAC 173-340)** is applicable for the establishment of cleanup levels for soil, groundwater, and ambient air in Palermo homes.

Groundwater. Under WAC 173-340-720, MTCA Method B is applicable to all sites. Use of MCLs as MTCA Method B groundwater cleanup levels is supported by the determination of the Washington State Department of Ecology Toxics Cleanup Program that MCLs that are at or below the 10^{-5} risk level (such as the MCLs for PCE and TCE) are sufficiently protective of human health. Therefore, Method B values (MCLs) for PCE and TCE are 5 $\mu\text{g/L}$ for both compounds and are applicable for groundwater at the

Palermo Wellfield. Operation of the air strippers at the Palermo Wellfield will clean up groundwater to these levels.

Surface Water. Under WAC 173-340-730, MTCA Method A cleanup levels for surface water must be as stringent as Washington State water quality standards and the National Toxics Rule (NTR) (see discussions of these ARARs below). Because Washington has not promulgated standards for TCE and PCE, and because the state references the NTR for protection of human health, the NTR standards are applicable as MTCA surface water cleanup levels. The NTR standards identified below will be met by cleanup of collected surface water using the aerated lagoon.

Soil. Under WAC 173-340-740 (Soil Cleanup Standards), Method B is the standard method for determining soil cleanup levels and is applicable to the Palermo Wellfield Superfund Site. The cleanup level at the Palermo site is based on protection of groundwater. The default formula for setting soil cleanup levels that are protective of groundwater is to use 100 times the groundwater cleanup level.

Because the human health risk assessment (Section 6.0) found no risk from COCs in soil, soil cleanup levels have been set at the Palermo Wellfield Superfund Site to be protective of groundwater. The calculated cleanup values are 0.0858 mg/kg for PCE and 0.398 mg/kg for TCE. These cleanup values are applicable to soil at Southgate Dry Cleaners where PCE and TCE concentrations in soil exceed the cleanup values. Operation of the soil vapor extraction system at Southgate Mall will achieve these cleanup values.

Air. Under WAC 173-340-750 (Cleanup Standards to Protect Air Quality), cleanup levels shall be based on estimates of the reasonable maximum exposure expected to occur under both current and future site use conditions. Therefore, for the Palermo Wellfield Superfund site, Method B is the applicable method for determining air cleanup levels. For hazardous substances for which sufficiently protective health-based criteria or standards have not been established under applicable state and federal laws, MTCA Method B air cleanup levels are derived using the human health risk equations and standard exposure assumptions of WAC 173-340-750(3)(a).

For indoor air in the Palermo neighborhood residences, the cleanup level for PCE is $4.38 \mu\text{g}/\text{m}^3$, and for TCE is $1.46 \mu\text{g}/\text{m}^3$. These values will be achieved by use of the french drain, which will lower shallow groundwater to reduce the source of air emissions.

- **Federal Clean Water Act Section 404 (33 USC § 1344) and implementing regulations (40 CFR § 230).** The approximately 1.5- to 2-acre area west of the Palermo neighborhood at the base of the bluff, where the french drain will be constructed, exhibits

features of a wetland. Therefore, federal wetlands protection requirements are relevant and appropriate. EPA will conduct an evaluation to determine the potential effects of the french drain construction and the means to minimize these effects. Best management practices will be followed to ensure that there are only minimal adverse effects on water quality and the aquatic environment.

- In accordance with **Federal Executive Order 11990 for Protection of Wetlands**, construction of portions of the remedial action in or near the wetlands area of the Palermo Valley will avoid adverse impacts, minimize potential harm, and preserve and enhance the wetlands to the extent possible by use of best management practices and careful siting of construction activities.
- **Washington Clean Air Act and implementing regulations (WAC 173-460-150); Olympic Air Pollution Control Authority (OAPCA) Regulation I, Section 9.16.** Air emissions at the site boundary must fall below the acceptable source impact limits (ASILs) set up for toxic air pollutants in WAC 173-460-150. ASILs for the COCs at Palermo are $0.59 \mu\text{g}/\text{m}^3$ for TCE and $1.1 \mu\text{g}/\text{m}^3$ for PCE. OAPCA Regulation I, Section 9.16 is applicable as well; it requires that any pollution control equipment such as the soil vapor extraction system be kept in good operating condition and repair. EPA will meet these limits through use of carbon filtration by the SVE system and through modeling of air stripper and lagoon emissions to ensure that they fall below the ASILs.
- **Washington Clean Water Act and implementing regulations (WAC 173-220-130) and the National Toxics Rule (40 CFR § 131.36)** are applicable to the discharge of water from the aeration pond to the Deschutes River. The discharge cannot exceed state water quality standards for PCE and TCE of $0.8 \mu\text{g}/\text{L}$ and $2.7 \mu\text{g}/\text{L}$, respectively. These are the human health protection standards for ingestion of water and organisms as determined by the National Toxics Rule. The lagoon will be designed to comply with the requirements, and the water will be monitored before discharge to the river to ensure that the applicable limits are met.
- **Washington Hazardous Waste Management Act and implementing regulations (WAC 173-303).** WAC 173-303-070 and 173-303-100 require an evaluation of spent activated carbon units from the soil vapor extraction system to determine whether they are dangerous wastes and are applicable at the site. If the spent carbon units are dangerous wastes, then EPA will accumulate, manifest, and transport them as required by WAC 173-303-170, 180, 190, and 200 to a facility that has been certified in compliance with applicable regulations. All off-site treatment, storage, and disposal of CERCLA waste will occur at facilities that are acceptable under the Off-Site Disposal Rule (40 CFR § 300.440).

- **U.S. Department of Transportation and Washington State Department of Transportation statutes and implementing regulations (49 CFR Parts 171 through 180); Washington State Transportation of Hazardous Waste Materials (WAC 446-50).** These regulations are applicable to the placarding and signage as appropriate to the transportation of spent activated carbon units.
- **Washington Water Well Construction Act and implementing regulations (WAC 173-160)** are applicable to eventual decommissioning of wells at the Southgate Dry Cleaners and wells that were installed for investigation and monitoring. The regulations require filling the well casing with grouting and placing a cap on top of the casing. EPA will follow these procedures in decommissioning the wells.

11.3 OTHER CRITERIA, ADVISORIES, OR GUIDANCE

This section discusses other criteria, advisories, or guidance considered to be appropriate for the remedial actions of the selected remedy for the Palermo Wellfield Superfund Site.

The State of Washington's *Statistical Guidance for Ecology Site Managers* (Ecology 1992a) and Supplement 6 to this guidance (Ecology 1993) are to be considered for the purpose of interpreting the sampling and analysis results at the Palermo Wellfield Superfund Site.

The State of Washington's *Stormwater Management Manual for the Puget Sound Basin* will be considered during design of the french drain and aeration lagoon, which will connect to existing storm water conveyance structures.

11.4 COST EFFECTIVENESS

The selected remedy for the Palermo Wellfield Superfund Site is one of the least costly combinations of alternatives evaluated for the various impacted media (groundwater, surface water, and soil). Taking no action to remediate one or more of the impacted media would be less costly than the selected remedy, but would not be protective of human health and the environment. Shortening the operational life of the SVE system at Southgate Mall would be less costly than the selected remedy, but would not meet chemical-specific ARARs for soil in this area.

The selected remedy is cost effective because it is protective of human health and the environment, achieves ARARs, and its effectiveness in meeting the objectives of the selected remedy is proportional to its cost. The selected alternatives are substantially more cost effective

than the other alternatives considered, while achieving comparable protection of human health and the environment.

11.5 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES OR RESOURCE RECOVERY TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE

The selected remedy for the Palermo Wellfield Superfund Site represents the maximum extent to which permanent solutions can be utilized in a cost-effective manner. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume. The selected remedy meets the statutory requirements for using permanent solutions to the maximum extent practicable. For groundwater and surface water, all of the action alternatives were found to achieve comparable overall protection of human health and the environment and to be effective. Therefore the alternatives considered to be most straightforward to implement and least costly were selected. For soil, the remedial action already taken was found to be effective and protective, and continuance of this action for soil was therefore selected.

It is not anticipated that any resource recovery technologies (e.g., recycling) will be practicable at the Palermo Wellfield Superfund Site. No substantial quantity of recyclable materials will be used in the remedy. The remedy will not recover any contaminant in significant quantity or in a pure form so as to allow reuse of the contaminant as a resource (such as sometimes is possible for fuel recovery).

Treatment of the collected surface water in an aerated lagoon "water hazard" at the municipal golf course is an alternative application of wastewater treatment technology to remediation. The lagoon design and aeration equipment are typically used in wastewater treatment plants, but are not typically used for contaminant remediation.

11.6 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

The selected remedy for the Palermo Wellfield Superfund Site includes the following treatment elements:

- Air stripping of groundwater at the Palermo Wellfield, which strips contaminants from water

- Air sparging of collected surface water from west of the Rainier Avenue residences, with treatment occurring at the City of Tumwater Municipal Golf Course, which strips contaminants from water
- Soil vapor extraction and carbon adsorption treatment of soil vapors at Southgate Mall, which filters contaminants out of soil vapor

In addition to these treatment elements, the remedy includes the non-treatment elements of monitoring and public education to prevent the new use of contaminated water.

11.7 FIVE-YEAR REVIEW REQUIREMENTS

The Five-Year Review is required pursuant to CERCLA Section 121(c) and the NCP Part 300.430 (f)(5)(iii)(C) because the selected remedy will result in PCE and TCE levels in groundwater at levels that do not allow for unlimited and unrestricted exposure throughout the site. The Five-Year Reviews will evaluate whether the remedy will remain protective of human health and the environment into the future. The first Five-Year Review will be conducted no later than 5 years after initiation of the Remedial Action. Five-Year Reviews will be conducted thereafter until COC levels allow for unlimited and unrestricted exposure throughout the site. For this site, Five-Year Reviews will be conducted until levels of COCs in groundwater meet cleanup levels throughout the site.

12.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan released for public comment on August 6, 1999, presented remedial action alternatives for the Palermo Wellfield Superfund Site. The proposed plan identified the preferred alternatives as Alternative 2 for groundwater, Alternative 8 for surface water, and Alternative 3 for soil. EPA reviewed all written and oral comments submitted during the public comment period for the Palermo Wellfield Superfund Site. The comments generally expressed support for the EPA preferred plan. However, several residents of the Palermo neighborhood indicated that there are houses beyond the west side of Rainier Avenue which contain standing water in their crawlspaces on a seasonal basis. This was new information to EPA. As the purpose of the Rainier Avenue french drain was to address only the groundwater under the houses along the west side of Rainier Avenue, it may have little or no effect on the groundwater table in the remainder of the Palermo Valley neighborhood. Therefore, during the remedial design phase of the project, EPA will conduct an investigation of the groundwater table throughout the Palermo neighborhood. If other houses are found to contain standing water in their crawlspaces, the water will be analyzed for COCs. If COCs are detected, the risk assessment methodology utilized in the Remedial Investigation will be used to assess risk to residents of the affected houses. If unacceptable risks are found, then remedial action will be taken consisting of lowering the groundwater table or ventilation of the crawlspaces, whichever is more cost-effective for lowering the potential risk to acceptable levels. These remedial actions are the same as those considered for the residences along the west side of Rainier Avenue. No other significant changes were necessary to the remedy for the Palermo Wellfield Superfund Site, as it was originally identified in the proposed plan, and to satisfy public concerns.

APPENDIX A

Responsiveness Summary

APPENDIX A RESPONSIVENESS SUMMARY

The responsiveness summary addresses public comments on the proposed plan for remedial action at the Palermo Wellfield Superfund Site. The proposed plan was issued on August 6, 1999. The public comment period was held from August 6, 1999 to September 6, 1999. A public hearing was held on August 17, 1999 to present the proposed plan and to accept oral and written public comments.

Four formal written comments were received. In addition to the written comments, members of the community had comments and questions that became part of the transcript of the public hearing. EPA addressed the questions that were posed during the hearing verbally, with the responses documented in the hearing transcript.

The comments received are summarized below, with responses provided for each comment. Responses are grouped by the overall subject of the comment. Comments provided by Chevron are summarized and addressed separately from the other community comments.

SUMMARIZED COMMUNITY COMMENTS

Potentially Responsible Party Concerns

A potentially responsible party (PRP) submitted a comment letter that indicated that they do not believe that they are responsible for contamination found at the site. EPA reviewed these comments and concludes that the data collected by EPA do, in fact, demonstrate that the party is responsible for contamination at the site. Prior to releasing the Proposed Plan, EPA notified a number of past and present owners believed to be responsible for contaminating the site. These people are referred to as PRPs.

Human Health Concerns

Comment: *How will the french drain help residents of the Palermo neighborhood that don't live along Rainier Avenue?*

Response: Several residents of the Palermo neighborhood have reported that crawlspaces of homes other than those along the west side of Rainier Avenue are prone to flooding. As a result of these assertions, EPA will include evaluation of the extent of crawlspace flooding in the neighborhood as part of the french drain design. If crawlspaces in additional homes are found to periodically flood, and contamination is found in the flood water, the proposed remedy will also address these homes. Expansion of the remedy could include additional drainage, installation of a deeper drain, or ventilation of specific crawlspaces. The selection process for an expanded remedy would be similar to that used for selection of the current remedy.

Comment: *The proposed french drain will move contaminated water to the "M" street storm drain. Is the capacity of this storm drain sufficient to handle the water from the drain plus storm events? If the drain leaks, won't the residents along "M" street be exposed to the contaminants, including vapors?*

Response: The "M" Street stormdrain currently carries contaminated water through a pipe from the existing drainage ditch west of Rainier Avenue to the eastern end of "M" Street. The stormdrain is under "M" Street, rather than directly beneath any homes, and is covered by soil and asphalt. The french drain system would continue to use this stormdrain for the same purpose, with increased flow. The design of the french drain will be performed in cooperation with the City of Tumwater, and the capacity of the "M" Street storm drain will be considered as part of the design. The stormdrain begins at the drainage ditch west of the Rainier Avenue residences, and so only needs sufficient capacity to carry the water from the french drain and some stormwater from the Palermo neighborhood. During the design data collection phase this winter, a survey of homes subject to crawlspace flooding will be conducted in the Palermo Neighborhood. If the M-street stormdrain is leaking with and resulting in exposure of residents along "M" street, this condition will be identified by the survey and addressed in the remedy design.

Comment: *Regarding "the lagoon and bubbling pool" at the end of "M" St., is that going to be adequately covered to protect animals and people from falling in (there are animals and elderly people in this location)?*

Response: The lagoon will be on the golf course, in an area that currently has some standing water. The animals in the area are presumably accustomed to water in this location and will be able to avoid the lagoon. The golf course as a whole is fenced to control access. Only golfers and golf course employees will have access to the lagoon, which will be treated as any other "water hazard" at the golf course. The lagoon is expected to be 6 to 8 feet deep. EPA will consult with the manager of the golf course with regard to the design of the lagoon and any safety features that are needed.

Comment: *When testing was first done in the Palermo area, two people came to our home and were given permission to test under our house. They told my wife not to stay under the house for prolonged periods. Later, they called to apologize for the comment. This really worried both of us.*

Response: EPA has found that there is a health risk posed by contaminant vapors being emitted from the water ponding in some crawl spaces in the Palermo neighborhood. The degree of risk was evaluated based on a very conservative mathematical model that assumes a long-term exposure of residents breathing air within the normal living space of their homes. In theory, the health risks would be greater if residents spent prolonged periods breathing the air from within the crawl spaces. This is a fairly unrealistic scenario, however, because crawl spaces are not suited to prolonged human occupation, and most residents spend limited time within them. Occasional time spent within crawl spaces in the Palermo neighborhood by residents is unlikely to significantly increase health risks. The comment of the field personnel in question, although technically accurate, was misleading with regard to the risks posed by the contaminants in your crawl space.

Comment: *Is the trichloroethene (TCE) coming up through the soil? Do the people on Rainier Avenue have a higher likelihood of tetrachloroethene (PCE) under their homes?*

Response: TCE vapors are emitted from the shallow groundwater, and either travel through soil where the groundwater remains below ground surface or vaporize directly into the air where shallow groundwater ponds on the surface. Both TCE and PCE have been detected in shallow groundwater in the area of Rainier Avenue. Farther east, PCE was not detected in shallow groundwater, but TCE was detected to the eastern edge of the Palermo neighborhood and into the Palermo Wellfield.

Comment: *Are we breathing TCE vapors? How far down did you find this chemical (what was the shallowest point)?*

Response: The presence of vapors that could pose a health risk in the Palermo residences has not been confirmed by direct sampling, so EPA can't say conclusively that residents are breathing such vapors. PCE and TCE were found in the crawlspace water. Modeling using basic chemistry and physics principles indicates that the PCE and TCE in crawlspace water will vaporize into the air above the crawlspace water and seep into the residences at concentrations that may pose health risks.

Comment: *Should we worry about gardening or digging in our yards due to contaminants in the soil?*

Response: Soil contamination has not been identified within the Palermo neighborhood, except in the sense that some PCE and TCE adheres to soil particles from the shallow groundwater. The health risk identified is from breathing vapors emitted from shallow groundwater, not direct contact with soil or groundwater. Gardening or other digging in residential yards does not pose a health risk.

Comment: *I understand that these chemicals can cause cancer, liver problems, kidney damage and harm your central nervous system. Is the government standard for determining individual susceptibility to these contaminants cast in concrete? Different people can have different reactions to the same chemical exposure.*

Response: There is not a government standard per se. The health risks of chemicals are assessed based on animal studies and limited human exposure data. These studies assess the effects of relatively high doses of chemicals and extrapolate to the comparatively low doses experienced in circumstances like those in the Palermo neighborhood. The extrapolation methods attempt to consider variations in individual response to chemicals, and are conservative.

Comment: *How did you come up with your numbers for determining the increased cancer risk for those with contaminants in their house crawlspaces?*

Response: We used the risk assessment modeling methodology of researchers Johnson and Ettinger for estimating the indoor air concentrations of PCE and TCE. Some conditions of this model were not met by a site with contaminated water at the soil surface. Therefore, we also used a similar model proposed by Karimi et al., sometimes called the Farmer Model to model the vaporization of volatile organic compounds (VOCs) from the crawlspaces vertically through the floor of the structure into the living space. Both the Karimi et al. and Johnson and Ettinger models attempt to predict the intrusion rate of vapors into a building.

VOCs are transported into homes through the floor. This happens when VOCs in the crawlspace water vaporize and this vapor spreads and moves upward through the floor of the house, eventually reaching the living space. The potential presence of VOCs in the home may pose a health risk to residents breathing household air. Inhalation risks were estimated based on the rate of diffusive flux of VOCs through the floor, and the average concentration of VOCs in living spaces.

Children's Health

Comment: *We're concerned about human health issues, especially when it comes to our children. Did EPA sample comprehensively for PCE and TCE? How can EPA be sure there is not more risk?*

Response: EPA collected over 450 soil samples and 700 groundwater samples to comprehensively assess the nature and extent of the contamination to the maximum practicable extent. Standard risk assessment techniques were used to evaluate the risks from the identified PCE and TCE contamination. These techniques (mathematical models) specifically considered health risks to children. The models used are very conservative, assuming constant, long-term exposure.

Comment: *Are children more susceptible to contaminants like TCE and PCE?*

Response: Yes, children are more likely to be exposed because they play vigorously outdoors (splashing, digging, and exploring) and they often bring food into contaminated areas. Because they are smaller (lower body weights than adults), they get higher doses per body weight; they are also shorter than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Their developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk management decisions, housing decisions, and access to medical care. The Agency for Toxic Substances and Disease Registry (ATSDR) concluded that these unique vulnerabilities of infants and children demand special attention in communities faced with contamination of their water, soil, air, or food.

Ecosystem/Habitat Concerns

Comment: *How will wildlife and existing plant life be protected during construction of the french drain and lagoon? Can you time the cleanup so it will be most protective of wildlife and habitat (construct french drain in fall rather than spring)? Certain seasons would be better than others. EPA needs to be sure that, when doing construction for the cleanup, older trees in the area are protected. If you dig the french drain using the existing ditch, there is a danger you will disrupt the trees' water supply, or have to remove some trees to construct the drain. This is a big concern for many citizens.*

Response: Over the winter EPA will be collecting information needed for design of the drain, such as depth to groundwater in the areas surrounding the drain alignment, extent of crawlspace flooding, and flow volume of the existing drainage ditch. During this time, EPA will also assess

the existing vegetation, and mark trees and other plants to be specifically retained. We will retain as much of the desirable existing vegetation as possible, such as shade trees, without compromising the effectiveness of the final drain. Construction impacts on animal habitat should be minimal and short-term because the construction effort is expected to require only a few weeks to 2 months and to cover only a relatively small area (about 2 acres total). The end result of the french drain construction is expected to result in a similar number of trees, with a less dense understory west of the residences, and increased human accessibility. Much of the wildlife habitat is expected to remain.

EPA will consider advantages and disadvantages of construction of the remedy during different seasons when the design is performed. Some compromises will have to be made in the decision process. For instance, although fall may be a better time for construction in terms of wildlife and habitat protection, waiting until fall would delay beginning to build the remedy and could result in construction taking place during a wet period (which would substantially complicate construction).

Comment: *Will the alignment of the french drain cross the private property of the residents of Rainier Avenue, as does the existing drainage ditch?*

Response: EPA's next task will be to collect detailed data regarding the existing topography at the base of the Palermo bluff, in order to choose the most appropriate drain alignment. Property rights issues and access agreements will be part of the drain design process. Conceptually, EPA anticipates that the drain will be located west of the residential properties along Rainier Avenue, entirely on the Capitol 5000 property.

Comment: *Based on a conversation with Louis Licht of Ecolotree, phytoremediation would be cheaper than the french drain. Why doesn't EPA ask him for a bid?*

Response: EPA has consulted phytoremediation experts at the University of Washington, and performed a treatability study to assess the effectiveness of phytoremediation at this site. The study concluded that phytoremediation would not be effective in this case. There is not enough land area to plant a sufficient number of trees to elicit the required drawdown of the water table. More importantly, the trees would do almost nothing to reduce the water table during the winter months, when the water table reduction is most needed.

Comment: *The area of the proposed french drain exhibits wetland species, and was once a true wetland. Won't the proposed french drain further dry out this area?*

Response: The french drain will be focused on drying out the area beneath the Palermo neighborhood. There are wetlands in the area where the french drain will be constructed, and they will be affected to some degree by the remedy. EPA believes that protecting the health of the residents of the Palermo neighborhood is a higher priority than preserving the area west of the Rainier Avenue residences exactly as it is now. The proposed french drain will leave substantial vegetation in place, and highly desirable vegetation, such as mature shade trees, will be preserved wherever possible. The end result of the french drain construction is expected to result in a more "park-like" setting west of the residences, with increased accessibility, and plenty of desirable vegetation. There will probably be less wetland-type vegetation, with a dryer forest understory and as many existing large trees as can be preserved.

Sampling Methods

Comment: *In 1993, when the City of Tumwater tested the water system for contaminants, did they know where the contaminants came from and in what direction they were flowing? How do TCE and PCE travel through the water system?*

Response: Until the comprehensive cleanup investigation was conducted, no one knew for sure what the sources of the contaminants were, or how they were moving to the wellfield. Earlier investigations provided parts of the whole answer, but a comprehensive study was needed to collect all of the information regarding the entire area. Now EPA has identified the sources of the contaminants, and know that the groundwater flow carries the chemicals from west to east, towards the Palermo Wellfield. Groundwater contamination does not extend past the wellfield to the east.

Comment: *What testing has been done to date? What is EPA planning to sample in the future? How extensive will the sampling be and how comprehensive?*

Response: EPA has collected and analyzed over 450 soil samples and 700 water samples to assess the nature and extent of contamination. EPA will continue to sample groundwater from monitoring wells throughout the area to track changes in the contaminant location and concentrations. The City of Tumwater will continue to sample the production wells at the Palermo Wellfield on a quarterly basis. EPA will also monitor the discharge from the lagoon and the groundwater elevation in the Palermo neighborhood.

Comment: *Will you sample our homes for TCE/PCE if we request it?*

Response: After the remedy has been implemented, EPA will sample the air in individual homes, if requested by the homeowner to do so. However, the homeowner should be aware of the

limitations and complications of sampling indoor air. Many items in typical households, from dry-cleaned clothes to building materials, emit the chemical vapors similar to those found in shallow groundwater in the area. This means that there is a high likelihood of misleading positive results from the air samples. PCE and TCE could be found in the air of Palermo neighborhood homes that has nothing to do with the presence of these contaminants in shallow groundwater beneath the homes.

Comment: *How often are levels of contamination in the water and groundwater being checked?*

Response: The groundwater being pumped at the Palermo Wellfield has been tested regularly since 1993. After the initial contamination was identified, testing was conducted weekly. Testing later dropped to monthly, and is now being done quarterly. The water in crawlspaces of the Palermo neighborhood homes has been tested once, last year (May 1998). Groundwater throughout the area was sampled on a quarterly basis using the wells installed during the RI, between March 1998 and December 1998.

Comment: *How do you take samples from a house crawlspace?*

Response: Samples of water from the crawlspaces collected so far have been grab samples from the sumps of the crawlspaces, collected with a bailer. Standing water in crawlspaces could also be sampled by opening the crawlspace accessary and dipping out a sample. Air can be sampled with field instruments (that don't really have the capability to detect the low concentrations of contaminants that would be present) or by collecting some air in a canister or bag and sending the container to a laboratory for analysis.

Cost and Potentially Responsible Parties (PRPs)

Comment: *Who will pay for all of the cleanup work (french drain)?*

Response: The work will be performed using federal money through the EPA. Ultimately, EPA will seek compensation from the parties responsible for the contamination, but that process will happen after the remedy is in place.

Comment: *Were other possible sources of the contamination (the old Mobil Gas station which used to be where the Jack in the Box is now) considered, besides those identified as PRPs? What is the problem with the Highway Department?*

Response: EPA thoroughly investigated the area to identify possible sources. Questionnaires were sent to a number of local facilities, including the gas stations mentioned in this comment.

EPA collected 450 soil samples and over 700 groundwater samples. Based on all the information collected, the only sources that were identified were the Chevron station, the WDOT Materials Testing Laboratory, and Southgate Dry Cleaners. At the WDOT Materials Testing Laboratory, trichloroethene was used to test materials, with the waste stored in an underground storage tank. But the system did not work very well, and its use was discontinued in 1970. The tank was found to still contain water and 15,000 part per billion of trichloroethene in 1995, and was subsequently removed.

Comment: *How can EPA hold certain parties responsible for the contamination when it's a past occurrence and most likely unintentional?*

Response: The contamination they caused may have been unintentional, but the legal responsibility for it remains with the parties that caused the contamination. The other choice is to hold the taxpayers responsible for contamination caused by someone else.

Comment: *When the dry cleaners now held responsible for part of the contamination first began operating, didn't they have to apply for a license from the City of Tumwater? Didn't the City check to see if the businesses were environmentally safe before issuing a license?*

Response: At the time the dry cleaner first began operation, they may not have been doing anything wrong, based on the existing laws and permitting processes. But when we trace the source of the contamination, we find that they are one of the sources. The contamination they caused may have been unintentional, but the legal responsibility for it remains theirs.

Comment: *Financial responsibility will be great for those supposed polluters who are required to pay. EPA needs to be aware of how this could harm the community economically.*

Response: EPA is sensitive to the issue of ability to pay, and does not intend to bankrupt any responsible party.

Economic (Houses, Property, Real Estate)

Comment: *How will dropping the groundwater level through use of the french drain affect house foundations? Won't the houses sink when the water is removed? Will this action lower real estate value?*

Response: The effect of lowering the groundwater level on nearby foundations will be considered during the design phase. EPA expects that lowering the groundwater level will increase, rather than decrease foundation stability, because the soils are relatively coarse-grained

and would therefore drain with little consolidation. Real estate value is based largely on perceptions of worth. A specific answer regarding the potential effect of contamination and remediation near your homes could best be provided by a real estate agent or real estate attorney considering your specific case. The remedy is not expected to detract from the quality of life in the neighborhood, and will reduce risk. Therefore, the remedy itself should not reduce property values. The presence of contamination in the area may affect property values, based on the perceptions of the potential buyers. The choice to have indoor air sampling conducted in your home may affect your disclosure obligations and property values.

Comment: What would our liability be, as property owners, if contaminants were found on our property? Would we need to report this at the sale of the house?

Response: Real estate specialists considering your particular situation would best answer this question. The choice to have indoor air sampling conducted in your home may affect your disclosure obligations and property values. You are probably obligated to disclose the overall investigation and cleanup.

Construction Concerns (Noise, Access, Length of Time)

Comment: *How deep will the french drain be? If it is close to our houses, will there be anything there to protect children after construction?*

Response: The precise depth of the french drain will be determined during the design phase, which is the next step in the process. We expect that the drain will be 4 to 6 feet deep, and will be located near the existing drainage ditch. The drain will be underground, and so will not pose a safety hazard to children.

Comment: *Won't the french drain only help with the water coming down the hill? How can it help clean the contaminants that are still in the ground below our home?*

Response: The remedy will be designed to reduce the risk from vapors emitted from shallow groundwater everywhere in the neighborhood where it is needed. The french drain will lower the groundwater some distance east of the bluff (the precise distance will be assessed during design). If the distance is not great enough to alleviate all of the crawlspace flooding, the remedy will be expanded to increase the drainage, or more easterly homes may have ventilation fans installed in their crawlspaces. The french drain will remove shallow groundwater, focusing on risk reduction. It will not remove contaminants from deeper groundwater, as these contaminants do not pose a risk to the Palermo residents' indoor air.

Comment: *1977 was a bad flooding season. What if the area floods again? How would this affect the french drain?*

Response: The french drained design will be based on information gathered throughout this winter, and will consider the possibility of abnormally wet years. The french drain will certainly reduce flooding.

Comment: *Heavy equipment will be used in constructing the french drain. What will the noise and dirt levels be? How will trucks hauling dirt and other materials access the back of Rainier Avenue?*

Response: Construction noise will be present at the golf course and along the french drain alignment during the day for a few weeks to two months. Dust emissions will be controlled with standard construction techniques, if necessary. Precise access routes have not been selected, but we expect to bring equipment in from the south, rather than along "M" Street. A temporary access road in that location would be improved.

Comment: *What kind of noise can the community expect from the lift station?*

Response: Because the lift station is an underground concrete vault containing only a sump pump, little or no noise is expected to be audible above ground.

Comment: *When will the french drain project be completed? We don't want a long wait. I'm personally in favor of the french drain proposal but I'm concerned about when it will be done. If we need to wait another year we'll just be exposed to more toxic air. You need to begin construction quickly while the water table is low.*

Response: EPA will move forward with design data collection, design, and implementation as quickly as is practical. First we need to consider and incorporate the public's comments, and then finalize the Record of Decision. We will need the upcoming wet season to collect design data, so construction cannot feasibly begin until next spring.

The risk assessment model that predicts an exposure risk utilizes very conservative assumptions, including a long term exposure. One additional year under current conditions is unlikely to result in any detrimental health effects. We can see no means of moving more quickly toward constructing the remedy.

Comment: *Where will you dig the french drain? Will you dig deeper within the existing ditch or create a new one?*

Response: EPA's next task will be to collect detailed data regarding the existing topography at the base of the Palermo bluff, in order to choose the most appropriate drain alignment and depth. Property rights issues and access agreements will be part of the drain design process. Conceptually, EPA anticipates that the drain will be located west of the residential properties along Rainier Avenue, entirely on the Capitol 5000 property. We expect that the drain will be completely underground, and will be 4 to 6 feet deep.

Comment: *If you use the existing ditch, you need to know that it might be a problem because the stormdrain at Rainier is clogged. The City needs to look into this.*

Response: The stormdrain clogging reportedly is the result of leaves and debris lodging at the junction of the existing drainage ditch and the "M" Street stormdrain. The french drain would be completely underground, so this debris problem would not be an issue. EPA will work with the City during the french drain design, to help assure that the completed drain functions properly.